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RAILWAY ACCIDENTS.

BOARD OF TRADE REPORT FOR THE YEAR 1886.

Block Signalling.

THE Board of Trade Report upon the accidents which have occurred on the railways of the United Kingdom during the past year records seven of the 62 investigated accidents as either wholly or partially due to a "defective system for securing intervals between trains or want of telegraph communication, or of block telegraph system." Of these six occur under the head "Collisions at Junctions," and one under "Collisions at Stations or Sidings." Appropriated to their several lines we find the list as follows:—Great Northern of Ireland, Great Southern and Western, Midland Great Western—all lines in Ireland—the North British and North Eastern, one each; and the London and North Western two.

That on the Great Northern of Ireland occurred on the 25th of December at East Wall Junction, where an up train from Belfast for Amiens Street, Dublin, came into collision with an empty passenger train proceeding to North Wall, while the latter was crossing from the down to the up line. The section of line is blocked at this point, but it would appear that from some cause the block had been temporarily suspended. Three passengers, two guards, and the signalman were injured by this accident, which forcibly illustrates the value of the block system, for there can be little doubt that had it been in operation at the time, the crossing operations would not have been allowed to proceed with a train in the section.

That on the Great Southern and Western took place on November 26th. As a down goods train was setting back at Portarlington Junction through a cross-over road from the down to the up line it was run into by a down passenger train. The driver of the passenger train alone was injured. The Board of Trade officer remarks with regard to this accident, "Had block working been in force between Monasterevan and Portarlington the collision could not have occurred.

That on the Midland Great Western took place on the 30th June, when a down goods train was run into by a down train of empty carriages returning from Dublin to Mullingar. The accident occurred at the latter station. The driver of the empty train was injured. Here, again, it is remarked that "the collision might have been avoided had the absolute block system been in force and properly worked between Mullingar and the station next it on the Dublin side."

The North Eastern accident occurred on the 14th of June at Whitby goods yard, where two goods trains came into collision. The main cause of this accident was the over-running of the signals by one of the trains. The Board of Trade Inspector, however, remarks, "Could the North Eastern Company see their way to adopting junction block working not only (as they now do) for passenger trains, but also for goods and mineral trains, the recurrence of a similar collision to the present would be prevented." A driver and guard were injured.

Of the two cases enquired into on the London and North Western system, one occurred on the 5th of June—a passenger train from Manchester for Buxton came into collision with a train for Crewe at Edgeley Junction; six passengers met with injury. The collision was due mainly to the carelessness of the driver of the Buxton train in allowing his engine to run past the junction signals, which were at danger; but the report adds: "The system of permissive block working, which allows two trains to be in the same block section, or to approach a junction at the same time, is dangerous."

The second case occurred on December 27th at St. Helen's Junction, where a passenger train came into collision with a goods train which was at the time crossing from the passenger to the goods line. The guard was injured. Here again it is remarked that "the system in force at this junction of sending a train forward under a *warning arrangement*, does not carry out the absolute block system of maintaining an interval of space between trains."

This completes the list of the accidents scheduled as applicable to the want of a proper means for insuring a space between trains at junctions. The remaining case comes under "Collisions within fixed signals," and occurred on the Glasgow District line on the 18th of March, when a North British train when stopping at Finnieston Station was run into by a following N.B. train. The block telegraph is in operation here and the line is ordinarily worked by it, but at the moment in question it was out of order. This led to two trains being in the same section. Still other causes helped to produce the accident. The starting signal was out of order and failed to come off for the first train, which accordingly drew up and waited for it to be lowered. The signalman was unaware of this. The man could not see the signal for steam and smoke issuing from the tunnel. The following train could not see that stopped at the signal from the same cause. It is suggested in order to meet any future case, that the signal cabin should be removed; but we would like to suggest also the propriety of "repeating" the signal. The case is one which points to the desirability of repeating all such signals, or signals similarly situated, and which may be obscured from view by smoke or steam at any time. Had the signal been provided with a "repeater" the signalman would have seen that on pulling over his lever for the first train to come forward he did not operate the signal, and naturally he would have taken other steps to relieve the train. Nine passengers and three of the company's servants were injured in this accident.

Under this heading "Collisions within fixed signals

at stations or sidings," 25 accidents were enquired into. Some 256 passengers and 30 servants of the companies concerned were injured, and two passengers and one servant killed—of the causes set down as occasioning or contributory to these accidents eight are said to be mainly due to mistakes of signalmen in block working, arising from forgetfulness or want of care. It is but fair to observe that some of the irregularities are attributable to suspension or irregularities in the block consequent upon the severe weather which prevailed during the winter period; but we cannot help remarking that were the electric signals interlocked with the mechanical signals, such mistakes would be very few and far between. The cost of such a combination would not be great and would be certain to repay itself by the casualties it would prevent. Railway companies have many claims for expenditure, doubtless, but there is none that would better repay the outlay than this. We are strengthened in this opinion by a remark appended to one of the reports, viz., that "the practice of signalmen wilfully breaking the block regulations, when they think they can safely do so, is far from uncommon," If this is so, then the sooner railway companies make it compulsory for the signalman to protect the traffic by the ordinary signals, the better it will be for the company and for the travelling public. This will only be effected by interlocking the two systems.

The report is, on the whole, satisfactory, although not quite up to 1885—62 cases have called for enquiry as against 60 in 1885. The proportion of passengers killed to the number of passenger journeys is 1 in 90,698,049, and of injured 1 in 1,179,812 as against 1 in 116,202,171 and 1 in 1,599,112 for 1885. It is very encouraging to notice the reduction in casualties year by year as the block has been increased. In 1876 the number of cases in which the want of it was the cause or contributary to it was 25. In 1885 this was reduced to 3. For the past year it stands as 7. There, however, still remains much to be done both in Scotland and Ireland—the latter especially. At the end of 1886, out of 12,946 miles of line open in England and Wales, 11,866 miles were worked upon the block system. In Scotland, out of 2,786 miles 2,249 were blocked. In Ireland, out of 2,607 miles only 524 were so worked. The proportion being 91 per cent. in England and Wales, 80 per cent. in Scotland, and 20 per cent. in Ireland.

NO sooner have we awakened from our "Reverie" than we are presented with two copies of the prospectus of the Water Primary Battery Company, Limited. How, in the name of all that is wonderful, anybody who is supposed to be in full possession of his senses, could concoct such arrant nonsense as is contained in this document, is one of those things which, Lord Dundreary would say, no fellah can understand. How touching it is to be told that children may handle the water battery without risk to themselves or danger to its efficiency. The vicious disposstion of nitric acid seems, somehow or other, to have been overlooked, but what of that! If for nothing else, Mons. D'Humy deserves credit for having invented a new toy for the rising generation. Once again we are treated to the well-worn and weighty argument that the battery gives off no noxious fumes, and that the danger and noise attending the use of the dynamo are avoided. The "tit-bits," in the way of newspaper extracts, which accompany the prospectus are, some of them, really very funny; but we notice with regret that our "Reverie" is not amongst the choice collection, probably because it might have discounted the favourable opinions of the rest. The report, too, of the eminent electricians who have examined the battery appear to possess a value which will doubtless much enhance their own reputation as experts, and captivate the British investor. Mons. D. Monnier, E.E., whoever this gentleman may be, says he has prolonged his trials of the battery less from a practical point of view than for the purpose of studying the chemical theory of the combination. We thought that the chemical theory of an iron-carbon-nitric acid and water pile had been left to us by a past generation. Mr. W. D. Gooch, too, concerning whose opinion there cannot be any question, states that "its action and principles are quite different from any of which I have any knowledge." This is probably due to the fact that Mr. Gooch commenced his electrical researches too late in life to enable him to become conversant with the earlier history of voltaic batteries. Mr. Gooch further states that the action and use of simple plain water in the outer cell is a conspicuous novelty, and the basis of the very satisfactory and economical results which M. D'Humy has obtained in electrical output. We are cognisant of the fact that water is good to drink, to wash with, and to swim in, but the atmosphere surrounding the battery, to which we *may* have to devote some further attention, is too D'Humid.

"THE three great precautions against loss of life by fire in theatres are, first and foremost, an iron curtain, which should be used at every performance; secondly, the use of electric light throughout the building; and, thirdly, double means of exit from all parts of the house. The Prince of Wales's Theatre has all these." So write Messrs. Sedger and Leslie, of the Prince of Wales's Theatre, Coventry Street, W. Our readers have probably still fresh in their memories the articles which appeared in the REVIEW immediately after the deplorable disaster at the Opera Comique in Paris, in which we so strenuously advocated the universal employment of the electric light and electric thermostats. We need do no more than refer to what we then said, and to express the hope that with the tragic scene enacted in Exeter Theatre on Monday evening, we have seen the last of these terrible casualties. The experiences of the Ring Theatre, in Vienna, the Opera Comique, the Jewish theatre at the East End, and others of a less serious nature, ought to teach those who are responsible for the safety of our playgoers a never-to-be-forgotten lesson. It appears certain that the Exeter disaster was occasioned by some portion of the stage-accessories—a gauze curtain—coming in contact with the naked lights, and electric lighting will now perhaps be generally enforced. In London, the frequenters of our theatres are comparatively safe, thanks to the Lord Chamberlain and the Metropolitan Board, but everywhere else apparently the safety of theatre-goers is left to the justices in special session, who may give or refuse a license at their discretion. Legislature being so far powerless, amusement seeking country folks are at the mercy of the moral responsibility of theatrical managers. The lesson taught at Exeter will doubtless bring about reforms of a salutary kind.

EXPERIMENTAL RESEARCHES ON THE ELECTRO-DEPOSITION OF ALLOYS.

By ALEXANDER WATT.

(*Concluded from page* 229.)

HAVING freely deposited a series of alloys from solutions of mixed metallic salts, not only with the aid of a very feeble current, but even by the simple contact of two strips of metal of opposite electric relation, and by the still more feeble process of simple immersion, I have arrived at the conclusion *that the deposition of positive and negative metals conjointly is independent of quantity of current, but is due solely to the electromotive force of the elements employed*, as, for example, zinc and steel (or iron) or zinc and the electrolyte, as in the case of the simple immersion results. To establish the above principle more positively, two thin wires, one of zinc and the other of steel, were placed in contact and immersed in a solution of the mixed acetates of copper and zinc, when the steel wire instantly received a yellow coating of brass. A further corroboration of the principle referred to was obtained in the following way :—Two strips of sheet zinc were taken, one of which was carefully amalgamated with mercury. Two strips of spring steel of corresponding size to the zinc strips were then obtained. With these four plates two couples were arranged, each having a layer of paper interposed, and the ends of each couple being put in contact. Both couples were then immersed in a mixed solution of the acetates of copper and zinc for a few seconds only, when they were removed from the liquid and dipped into cold water. On examination, the steel plate which had been in contact with the amalgamated zinc, was found to be well coated with a yellow deposit of brass, while the corresponding steel plate which had been in contact with the unamalgamated zinc was only slightly tinted with the alloy. It thus became evident that the E.M.F. of the first couple had been augmented by the amalgamation of the zinc, and hence a more rapid reduction of the constituent metals was the result.

In referring once more to Prof. Silvanus Thompson's interesting "Note on the electro-deposition of alloys, and on the electromotive forces of metals in cyanide solutions," some observations occur which it will be necessary to quote here, although they refer to experiments made with solutions differing entirely from those with which my own results were obtained. In making these extracts it will be advisable to put in *italics* such points as have a special bearing upon the comparative results obtained by Prof. Thompson and myself and the deductions drawn from them in each case. "Since the degree of concentration of the solution greatly affects the electromotive force of the metal, and since in the act of deposition of a metal from its solution, the concentration of the liquid around the cathode is reduced, owing to the slowness of diffusion, it follows that in electro-deposition the counter E.M.F. at the cathode will vary with the rate at which the metal is being deposited, and will therefore vary with *the current density* employed. And since, moreover, the variations in E.M.F. due to differences of concentration are greater for copper than for zinc, it follows that in the deposition of brass from a mixed solution of cyanides of a medium concentration, in which zinc is slightly more electro-positive than copper, there will be a certain *density of current* with which the metals will be deposited in nearly equal quantities, while *for weaker current densities* the less electro-positive metal will be deposited in excess, and for *stronger current densities* the more electro-positive metal will be deposited in excess. Hence to variations in the concentration of the electrolyte near the cathode are due the departures, *observed with all currents, except weak ones*, from the law that out of a solution of mixed metals the least electro-positive metal is deposited first." Without in the least degree questioning the soundness of Prof. Thompson's views, so far as they relate to the electrolysis of cyanide solutions, yet how widely do they differ from the results which I have obtained with *acid solutions*, where the "departures" from the accepted law are so numerous as to render its abrogation, one would think, a necessity. When it is borne in mind that, as I have shown, deposits of alloys can be readily obtained from acid solutions of mixed metallic salts *without the aid of a direct current*, it will be seen that the passages in Prof. Thompson's paper which I have emphasised by *italics* (solely for the purposes of argument) do not, and cannot, apply to the electro-deposition of alloys from such solutions, or at least the deposition of alloys from acid solutions is not dependent upon the conditions of current referred to in the passages quoted. Having made these few, but necessary introductory remarks, I will now proceed to give the details of some further experiments which I made in pursuing this interesting subject.

EXPERIMENT XI. *Phosphates of Copper and Zinc.*—In this case it was found necessary to employ a very weak solution of the mixed salts, the same battery being used as in the preceding experiments. With a brass anode and steel plate for the cathode the latter received a yellow deposit of brass immediately after immersion, so soon as the solution had been sufficiently reduced in strength, by repeated additions of water, to yield the required deposit; when in a more concentrated condition a blackish deposit only was obtained, as in many other instances.

By Contact.—A strip of steel in contact with a strip of zinc received a yellow film of brass in the same solution.

By Simple Immersion.—A strip of zinc when gently moved about in the liquid became coated with a yellow film, but not of very good colour.

XII. *Chlorides of Copper and Cobalt.*—It was found necessary to employ a weak solution of the mixed salts in this case also, when with the direct current an alloy somewhat of the colour of gun-metal was obtained upon a steel surface. There was some little difficulty in getting the two metals to deposit simultaneously, but this was overcome by regulating the anode surface, and by occasionally wiping the surface of the cathode —when the deposit was inclined to be pulverulent— and then re-immersing it in the bath.

By Contact.—On a strip of steel in contact with a strip of zinc a deposit resembling gun-metal was obtained.

By Simple Immersion.—A strip of zinc when kept in motion in the above liquid received a film of the same character as above.

XIII. *Sulphates of Copper and Iron.*—In this experiment a tolerably strong solution of the mixed sulphates was taken, the iron salt being in excess. With the direct current a *graduated film*, so to speak, of a more or less bronzed appearance was obtained on a steel plate, iron being more conspicuous at the lower end of the cathode, and copper at the upper end nearest the surface of the liquid, while the intermediate space was more or less brown or bronze coloured, the tone becoming warmer or more coppery towards the upper end of the electrode. The opposite side of the steel plate—the surface which had not been opposed to the anode—exhibited the same characteristics, but in a less marked degree, copper being chiefly, but not alone, deposited on this surface.

By Contact.—A strip of steel and a strip of zinc, with a layer of paper interposed, were united at their upper ends, and the plates then immersed in the above solution for about fifteen seconds, and then removed and rinsed in water. A deposit of an irregular character, but evidently a combination of the two metals (copper and iron) appeared on the steel surface. A strip of each metal—steel and zinc—were next placed in close contact and immersed in the liquid, when a film similar to the last was obtained on the steel.

By Simple Immersion.—A strip of sheet zinc being immersed in the liquid at once assumed a black colour; when this was wiped and the plate returned to the liquid and kept in brisk motion, a film presenting all the appearance of an alloy was obtained, and the same result was readily repeated upon other strips of metal by *stirring the liquid briskly* with the piece of

zinc. I may here state that I have frequently found, when adopting the simple immersion method of deposition, that in those cases where it is difficult to get two metals to deposit simultaneously, by briskly stirring the solution with the strip of metal I could obtain an alloy which was often impracticable under other conditions.

XIV. *Chlorides of Copper and Antimony.*—A weak and very acid solution of the mixed metals was employed in this experiment, and some difficulty was experienced in getting both metals to go down at the same time. Almost immediately after immersion in the bath the cathode received a film of a dense black colour; this being wiped with the finger, a slight evidence of an alloy appeared on the surface beneath, and the plate was again dipped, with the same result. By repeated dipping and wiping both sides of the plate an adherent film of a gun-metal colour was obtained on both surfaces, which well resisted the pressure of the burnisher.

By Contact.—A piece of polished steel in contact with a strip of sheet zinc promptly received a film, the colour of which closely resembled that of gun metal, but of a somewhat more pleasing tone.

By Simple Immersion.—The deposit on zinc was of a yellower colour than the preceding, and the alloy could only be obtained by briskly moving the strip of metal about in the liquid.

XV. *Acetates of Copper and Lead.*—A moderately strong solution of the mixed salts was used, but there was much the same difficulty in getting both metals to deposit at once, as in the last case (experiment 14). By *manipulating* the electrodes—giving gentle motion to the negative plate while in the bath—a pinkish alloy was obtained upon the steel surface facing the anode, while the opposite side received a film at the lower part of its surface of a similar character.

By Contact.—A strip of steel in contact with zinc received a coating almost precisely of the same colour as the foregoing.

By Simple Immersion.—A strip of zinc when slowly moved about in the above solution became coated with a pinkish film, much resembling in tone of colour the two previous coatings.

XVI. A strip of sheet zinc in contact with a strip of aluminium became freely coated with brass of good colour, and very adherent, in a solution of the citrates of copper and zinc, while the aluminium itself received a slight coating of copper only.

XVII. A piece of zinc wire was formed into a helix, and a straight steel wire then passed through the coil; the wires thus arranged were then immersed in a solution of the acetates of copper and zinc, when the steel wire at once became coated with brass of good colour. The object of this arrangement was to obtain an uniform coating of alloy on the cylindrical surface of the steel.

XVIII. A polished nickel-plated surface, in contact with zinc, received a coating of brass in several mixed metallic solutions, as in the acetate of copper and zinc, citrates of copper and zinc, &c.

XIX. *Sulphates of Copper, Nickel, and Zinc.*—In this experiment an attempt was made to deposit, conjointly, the three metals which form the alloy known as German silver. Although the experiment having been somewhat hurriedly performed, was not wholly successful, there was apparently some evidence of the triple deposit, and I hope to be more successful in future trials in the same direction.

XX. *Chlorides of Copper and Platinum.*—A very weak solution of the mixed salts was prepared, and a steel plate used as a cathode as before. Almost immediately after immersion the steel plate became coated with a black deposit; this was wiped off, and the plate re-immersed and vigorously moved about in the solution, when it assumed a more coppery hue; this film, when rubbed between the fingers, exhibited a pale copper colour or pinkish tint, indicating that a small quantity of platinum had deposited with the copper. Subsequent experiments gave more decided evidence of an alloy of these metals. A strip of zinc immersed in the same solution received a loose black coating of platinum only.

It would appear from the results obtained in the foregoing experiments, that the deposition of alloys from acid solutions—when the proper condition of the electrolyte has been arrived at—is far from being so difficult of accomplishment as was generally supposed. Indeed, when the proper *knack*—to substitute a homely phrase for the word manipulation—has been acquired, there seems little or no difficulty in the matter; indeed, so far as I have gone, I am disposed to think that there is scarcely a limit to the number of alloys that may be deposited from solutions of mixed metals. Believing this to be so, I have devised a long series of experiments, which I purpose following up from time to time, as other engagements may permit, and the results of these I hope to make known at no distant date. Having carefully preserved the solutions from which I obtained the results recorded in these papers, I shall be prepared to repeat the experiments hereafter in the presence of others, should such a demonstration be desirable.

EARLY SECONDARY GENERATORS OR INDUCTION COILS.

By RANKIN KENNEDY.

IN an early patent, dated 1856, No. 3,059, granted to Cromwell Fleetwood Varley, two forms of induction coils are illustrated and described in detail which are entirely similar to two of the latest and most successful forms of converters or induction coils. One of them consists of a perfectly laminated closed magnetic circuit coil, which if made strictly to this specification would give the highest results as a transformer or induction coil for use in a distribution system. It consists of "a bundle of iron wires (fig. 14), which instead of being made of about the same length or a little longer than the coil, as has hitherto been done, is made of rather more than three times the length, and its ends are bent back as shown, so as encase the whole coil with iron wire, excepting a space purposely left, through which the ends of the primary and secondary wires pass. By thus encasing the coil with iron the quantity of electricity circulated (induced) in the secondary wire is very much greater."

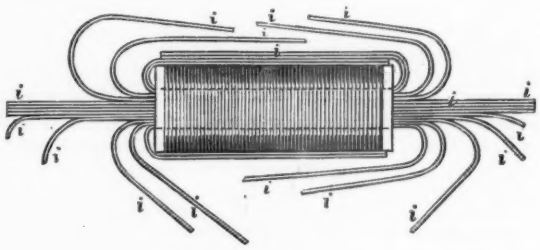


FIG. 1.

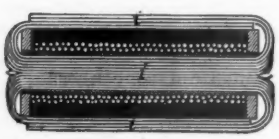


FIG. 14.

These statements between the commas are copied from the specification. I annex fig. 14, which is also taken from the specification. Fig. 1 is a drawing I have made showing the coil of copper wires with the long bundle of iron wires ready for folding over. Anyone who is interested in transformers can easily from these figures and the above extract from the specification make an efficient and very simple transformer of the most successful type.

In another fig. (15) in the same specification we have another induction coil with closed magnetic circuit

and also with a sub-divided magnetic circuit, only no attempt is made to laminate the cores; they may, however, be laminated easily. This induction coil consists

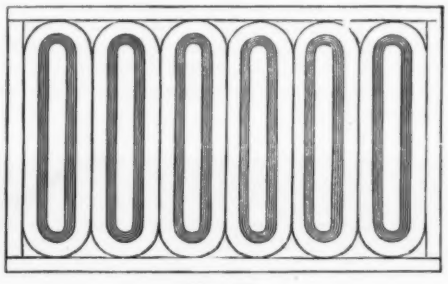


FIG. 15.

of a number of small flat iron cores, each wound with a primary and secondary wire, and placed on end with the one end of the core in contact with the bottom of an iron box, they fill the box entirely, and the lid, which is entirely of iron, is put over all so as to connect all the upper poles of the small induction coils. Fig. 2 shows an elevation in section.

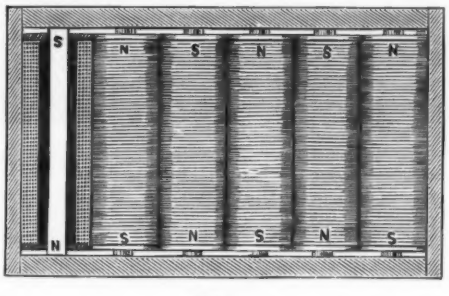


FIG. 2.

This specification, taken along with the others mentioned in my former articles, settles the question as to priority of invention of the closed magnetic circuit in induction coils; but since writing these articles I have received letters discussing the claims of the various later inventors. Now this subject must be discussed under at least three distinct heads:—

1. *The Invention of the Transformer.*—This must be treated alone, as it does not at all follow from the fact of an inventor having invented and made a perfect transformer, that he has invented a system of distribution of electric energy.

2. *Systems of Distribution.*—These inventions of systems must be treated altogether apart, as an inventor might devise a successful system of distribution by transformers, without being called upon to prove that he invented the transformer.

3. *The Transmission of Electric Energy to a Distance.*—This is a very different problem from the distribution of electric energy. A complete plant which could be successfully employed for distribution purposes could also be applied to transmission; but a plant might be perfect for transmission purposes, and be at the same time totally incapable for distribution purposes.

I have fully discussed the transformer patents, but we may again refer to the various systems.

In the specification describing systems such as Jablochkoff's, 1877; Edwards and Normanby, 1878; J. B. Fuller, 1878; Bright, De Meritens, and Gaulard and Gibbs up till 1883, each and all of them describe systems employing transformers placed in series order; they are all alike, and not one of them could distribute electric energy for any purpose whatever; any of them could transmit electric energy to a distance and transform it, but that is not distribution.

For distribution of electric energy among a number of independent consumers all the proposals and patents dating prior to 1883 are utterly worthless and impracticable for distribution purposes.

The invention which was wanting in all the schemes and systems to make them successful, was a method whereby each consumer in a system would obtain an independent supply without interfering with his neighbour's supply, and the discovery of self-regulation in parallel transformers and placing them in parallel order solved that problem.

The first English patent for this parallel system is Zipernowski and Deri's 1885.

It is exceedingly difficult to perceive where or how any inventor or patent claimant can set up a broad controlling claim over these systems or any essential part of them. The transformer or induction coil is a very old invention, the use of it in a system of distribution for electric lighting dates back 30 years nearly, and has been patented a score of times during the past 10 years, and the only successful system, namely, the parallel system was published by me in 1883.

It would be interesting to know upon what claims M. Gaulard has been successful on the Continent in his patent cases against Zipernowski and Deri's. I have studied the whole subject from the British patent point of view, and must confess that I cannot discover what M. Gaulard has invented which was not to be found in a few prior specifications, and I have yet to learn that any specification prior to 1884 or '85 describes a method of distribution by transformers which will *distribute* at all.

SELF-INDUCTION AND ITS MEASUREMENT.

By E. C. RIMINGTON.

(*Continued from page* 210.)

To find the value of ϕ we have:

$$\sin(at-\phi) = \frac{b}{\sqrt{a^2+b^2}}\sin at - \frac{a}{\sqrt{a_2+b^2}}\cos at$$

This equation must hold for all values of t, so let $t=0$.

Then
$$\sin\phi = \frac{a}{\sqrt{a^2+b^2}}$$

Again, let
$$at = \frac{\pi}{2}.$$

Then
$$\cos.\ \phi = \frac{b}{\sqrt{a^2+b^2}}$$

or
$$\tan\phi = \frac{a}{b} = a\ .\ \frac{L}{R}$$

So we have

$$i = \frac{E_0}{\sqrt{R^2+a^2L^2}}\sin(at-\phi) + C\,e^{-\frac{R}{L}t}$$

where
$$\phi = \tan^{-1}\ a\ .\ \frac{L}{R}$$

The term $C\,e^{-\frac{R}{L}t}$ relates to the momentary growth of current when the circuit is first closed, and becomes so small after a very short time that it can be neglected.

If $L=0$
$$i = \frac{E_0}{R}\sin at = \frac{E}{R}$$

We thus see that the effect of self-induction in a circuit is to increase its apparent resistance from R to $\sqrt{R^2+a^2L^2}$, and to retard the phase of the current.

The E.M.F. is a maximum when $at = \frac{\pi}{2}$, or when $t = \frac{\pi}{2a}$, but the current is a maximum when $at = \frac{\pi}{2} + \phi$, or when $t = \frac{\pi}{2a} + \frac{\phi}{a}$; that is to say the cur-

rent is in any particular phase $\frac{\phi}{a}$ seconds after the corresponding phase in the E.M.F.

ϕ is called the angle of retardation and $\frac{\phi}{a}$ the time of retardation.

Since $\sin\theta$ passes through all its values when θ increases from 0 to 2π, if we denote by T the period of the E.M.F. (*i.e.*, the time it takes to pass through all its values, both positive and negative, or make a complete alternation), a T must equal 2π, or $a = \frac{2\pi}{T}$.

So we may write

$$i = \frac{E_0}{\sqrt{R^2 + \frac{4\pi^2 L^2}{T^2}}} \sin\left(2\pi\frac{t}{T} - \phi\right)$$

and

$$\phi = \tan^{-1}\frac{2\pi L}{R T}.$$

This is the form in which the equation for i is generally written.

Again, if n be the number of periods per second, or half the number of reversals of current per second $n = \frac{1}{T}$

So

$$i = \frac{E_0}{\sqrt{R^2 + (2\pi n L)^2}} \sin(2\pi n t - \phi)$$

and

$$\phi = \tan^{-1}\frac{2\pi n L}{R}$$

For the benefit of those readers who may not be able to follow the solution of the differential equation given above, the following simpler but less complete method of finding the value of i is given. As before, write

$$E = E_0 \sin a t$$

If the E.M.F. in the circuit follows the sine law, the current will follow the same law; but, if there is self-induction in the circuit, we cannot say that the current at any instant equals the E.M.F. at the same instant divided by the resistance of the circuit; neither do we know that the phase of the current will agree with the phase of the E.M.F.

We should therefore write $i = A \sin(a t - \phi)$; where A and ϕ are constants, depending on R, L and a.

Taking the fundamental equation

$$E = i R + L\frac{d i}{d t}$$

we have

$$E_0 \sin a t = A R \sin(a t - \phi) + L\frac{d}{d t} A \sin(a t - \phi),$$

or $$E_0 \sin a t = A R \sin(a t - \phi) + A L a \cos(a t - \phi).$$

This equation must hold for every value of t; so let $t = 0$.

Then $$A R \sin\phi - A L a \cos\phi = 0,$$

or $$\tan\phi = a\frac{L}{R}.$$

Again, let $$a t = \phi.$$

Then $$E_0 \sin\phi = A L a,$$

or $$A = \frac{E_0 \sin\phi}{L a}.$$

Now

$$\sin\phi = \frac{\tan\phi}{\sqrt{1+\tan^2\phi}} = \frac{a\frac{L}{R}}{\sqrt{1+\frac{a^2 L^2}{R^2}}} = \frac{a L}{\sqrt{R^2 + a^2 L^2}}$$

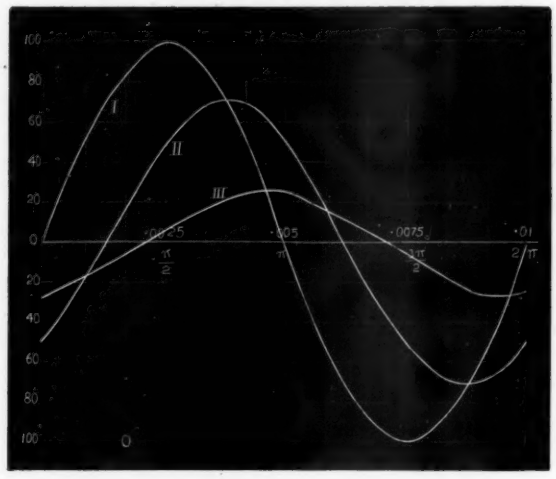
Therefore $$A = \frac{E_0}{\sqrt{R^2 + a^2 L^2}}$$

And

$$i = \frac{E_0}{\sqrt{R^2 + a^2 L^2}} \sin(a t - \phi); \text{ where } \phi = \tan^{-} a \cdot \frac{L}{R}$$

This is the same result as was obtained before, but it does not take into account the term $C e^{-\frac{R}{L}t}$

The curves in the figure represent these results. I. is the curve connecting the E.M.F. and the time; the maximum value of the E.M.F. is taken as 100, the value of a is 200π or 628·3, so that T, the periodic time, is ·01, or the complete alternations are at the rate of 100 per second.



If the resistance of the circuit be taken as 1 ohm and there be no self-induction, the curve connecting the current and the time will also be represented by I. II. is the curve for current when the co-efficient of self-induction is equal to $\frac{1}{200\pi} = ·001592$. As $\tan\phi = a \cdot \frac{L}{R} = 1$ in this case, $\phi = \frac{\pi}{4}$, so that the angle of retardation is $\frac{\pi}{4}$, and the time of retardation is ·00125 of a second. The maximum value of the current, instead of being 100 as in I., is

$$\frac{100}{\sqrt{1+1}} = \frac{100}{\sqrt{2}} = 70·7.$$

In III., $\phi = \frac{3\pi}{8}$, and $\frac{a L}{R} = \tan\frac{3\pi}{8} = 3·732$, whence $L = \frac{3·732}{200\pi} = ·00594$, and time of retardation = ·001875 of a second. The maximum value of the current

$$= \frac{100}{\sqrt{1+3·732^2}} = 25·9.$$

It is obvious that ϕ can never be greater than $\frac{\pi}{2}$, in which case $a \cdot \frac{L}{R}$ must be infinite, which means either L must be infinite or the period zero. As neither of the latter conditions are practically possible, ϕ is always less that $\frac{\pi}{2}$.

Inspecting the formula $i = \frac{E_0}{\sqrt{R^2 + a^2 L^2}} \sin(a t - \phi)$ we see that if a be very large, the value of $a^2 L^2$ may became very large compared to R^2, so that, in a circuit where the number of alternations is very rapid, the current depends far more on the value of L than on the resistance of the circuit.

The algebraical value of the quantity of electricity which passes through the circuit during a time equal to the period is of course zero, as equal quantities pass during each half period, but in opposite directions. We can, however, find the quantity passing in a half period thus:

$$Q = \int_o^{\frac{\pi}{a}} i\,d\,t = \frac{E_0}{\sqrt{R^2 + a^2 L^2}} \int_o^{\frac{\pi}{a}} \sin a\,t\,.\,d\,t$$

$$= \frac{E_0}{a\sqrt{R^2 + a^2 L^2}} \int_o^{\pi} \sin a\,t\,.\,d\,.\,a\,t$$

$$= \frac{E_0}{a\sqrt{R^2 + a^2 L^2}} (-\cos\pi + \cos 0) = \frac{2\,E_0}{a\sqrt{R^2 + a^2 L^2}}$$

We do not here take into account ϕ, as the quantity passing through the circuit in any given time is obviously independent of ϕ, as an inspection of the curves connecting i and t will show.

The quantity passing during a period, disregarding sign, will be $2Q$.

The *mean* current (*i.e.*, the value of a continuous current that would send the same quantity through the circuit in any given time as is sent by the alternating current in that time) is found by dividing Q, the quantity passing in the half period, by $\frac{\pi}{a}$ (the half period); or

$$i_m = \frac{2\,E_0}{a\sqrt{R^2 + a^2 L^2}} \times \frac{a}{\pi}$$

$$= \frac{2}{\pi} \cdot \frac{E_0}{\sqrt{R^2 + a^2 L^2}}$$

$$= \frac{2}{\pi} \times \text{the maximum value of the current.}$$

$$= \cdot 6366 \times \text{the maximum value of the current.}$$

(To be continued.)

ON THE THEORY OF THE DYNAMO.

By O. FRÖLICH.

(Continued from page 232.)

Further were examined the rings of two new machines, H_5 and H_6, with cast iron limbs and magnets, little copper on the ring and much iron in the limbs, and an older machine D_2, with wrought iron limbs, much copper on the ring and little iron in the limbs. For the former machines the results were :—

Machine H_6.

Number of rotations.	Resistance of ring.
0	0·201 ohm.
600	0·233 „
800	0·257 „
900	0·300 „

Machine H_5.

0	0·145 „
600	0·231 „
800	0·267 „
900	0·287 „

In the machine D_2 the iron of the limbs was first entirely removed, and the machine was set upon a wooden frame (A); then an iron frame was substituted for the latter, and lastly legs were again applied (C).

Machine D_2.

A. Without limb irons, on wooden frame.

Number of rotations.	Resistance of ring.
0	0·300 ohm.
600	0·517 „
1100	0·911 „

B. As above, but on iron frame.

Number of rotations.	Resistance of ring.
0	0·302 ohm.
600	0·580 „
800	0·730 „
900	0·835 „

C. With limb irons, on iron frame.

Number of rotations.	Resistance of ring.
0	0·31 ohm.
600	1·74 „
1100	3·62 „

Each measurement is the mean of several single measurements; fig. 8 represents the results graphically. It will be seen that the increase of the resistance of the ring in D_2 is the greater the more iron is found about the ring; of course the self-induction increases likewise. Very remarkable is the enormous increase in the machine D_2 when completely put together.

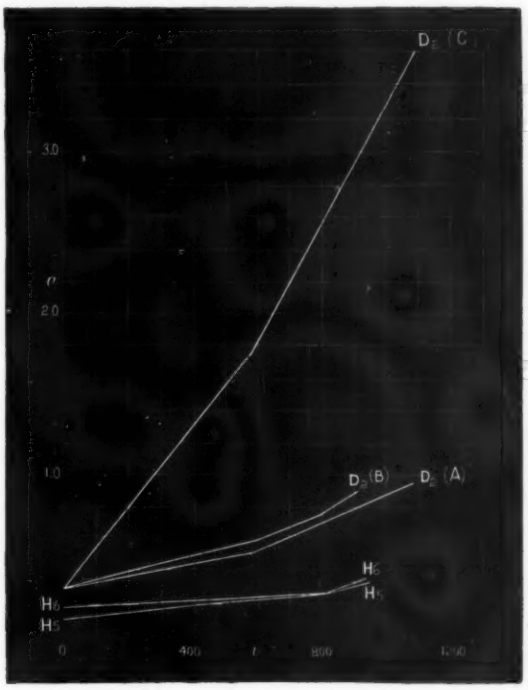


FIG. 8.

These measurements seem to prove that an increase of the resistance of the bridge really takes place; from the earlier measurements of Cabanellas and of Ayrton and Perry with the ordinary bridge I was unable to judge whether the influence of the electromotive force was completely avoided, and whether the increased resistance observed was not perhaps unreal.

Measurements of self-induction were likewise executed on the above-mentioned machines, but their utilisation with reference to the above determinations of resistance must be postponed to a future occasion.

EQUALITY OF THE ELECTRIC AND MECHANICAL WORK IN THE MACHINE.

The difference between the electrical and the mechanical work forms a further stumbling block in the theory of the dynamo machine. In small machines this difference is in great part explained by friction in the bearings and by the resistance of the air. In larger machines these quantities are trifling in comparison with the total work, and if we take these frictions into account there still remains a notable difference between the two kinds of work, which calls for explanation.

In the earlier machines it is probable that this residue comes from the induction currents in the ring. In the establishment of Siemens and Halske there were made at one time direct measurements of this work (see *Elektro. Tech. Zeitschrift*, 1885, p. 65), showing that its quantity was considerable.

In the case of more recent machines the correctness of this explanation becomes doubtful, for it has been

gradually found advisable to construct the armatures so that only trifling induction currents are produced. This may be judged from the fact that if the limbs of the magnet are magnetised, and if the ring is allowed to rotate with the brushes removed the ring scarcely becomes perceptibly heated.

Since I began to measure the increase of the resistance of the ring with the increasing speed, and to observe the great influence of this point upon the electric conditions, the suggestion presented itself that the unexplained difference of the mechanical and the electrical work has its origin in this circumstance. For the electromotive force cannot be observed, but merely calculated from the polar tension and from the resistances in the machine and the strengths of the current. The greater the resistance of the ring is assumed to be the smaller becomes the difference between the mechanical and the electrical work.

At Siemens and Halske's establishment experiments have been made on this subject. Unfortunately they are not free from objections, so that they have not been published, but require to be repeated. I have, however, derived from them the conviction that the difference between the electrical and mechanical work disappears entirely, or nearly so, if we take into account the increased resistance in the armature.

ON THE CONSTANCY OF THE CONSTANTS IN MY REPRESENTATION.

Doubts have been repeatedly expressed whether the constants of the ring and the limbs employed in my representation really have the signification which I have attributed to them, especially if the so-called ring-constant does not depend on changes in the limbs. I may remind the reader here of the opinions of Weinhold (*Elektro. Techn. Zeitschrift*, 1886, p. 131) and Von Waltenhofen (*Zeitschrift für Elektrotechnik*, 1886, p. 457).

This point can be experimentally decided if we undertake changes in the limbs, and each time determine the constants. The ring constant must then remain alike, and the constants of the limbs must change in accordance with the alterations made. For this purpose the following experiments are suitable:—

1. Alteration of the iron of the limbs of the magnets.
2. Different intercalations of the wrappings of the limbs.
3. Examination of the machine as recipient and as generator (primary and secondary).
4. Separate treatment of the wrapped parts of a machine with compound wrapping.

1. Guinand applied three different pole pieces in the machine with which he worked and determined the constants each time. The results, both with direct working and with working in a shunt without external resistance, agree fairly with my representation. They deserve mention here, although the experiments with a shunt arrangement with external resistance are not yet satisfactorily explained; for the increase of the resistance of the armature (not taken here into account) and the demagnetising action of the armature currents are of less importance in the former experiments.

2 and 3. On altering the number of the coils on the limbs an essential difference appears between direct and indirect working. The more the limbs are inserted parallel in case of direct working the more rapidly the machine must run, or the smaller must be the exterior resistance if the machine is to yield its normal tension and strength of current. In case of a shunt the reverse holds good and the differences of speed or of exterior resistance are less than in case of the former. Hence it follows that in direct working the increased resistance of the armature comes more into play than in a shunt, as it appears from the experiments which we are about to cite.

Of these experiments I adduce in the first place those which are mentioned in my book, p. 76, in which the increased resistance of the armature is not regarded.

On an earlier machine, C_{18}, of Siemens and Halske, a strictly shunt machine, without exterior resistance, experiments were made with the limbs of the magnets placed in succession, doubly parallel and four-fold parallel, with the following results:

A.—*Limbs in Succession.*

v:	450	500	550	600	650
P_∞:	8·15	9·69	11·2	12·8	14·4

B.—*Limbs Doubly Parallel.*

v:	250	300	350	400	450	500	550	600
P_∞:	4·23	5·86	7·21	8·79	10·2	11·6	13·0	14·7

C.—*Limbs Four-fold Parallel.*

v:	250	300	350
P_∞:	4·6	5·9	7·0

If the respective curves are plotted out and the mean right line dotted, we obtain the following values according to the formula:

$$P_\infty = \frac{f \cdot v}{1 + \frac{a}{n}} - \frac{P_i}{1 - \frac{a}{n}}$$

$$A: \frac{f}{1 + \frac{a}{n}} = 0{\cdot}0313, \quad \frac{P_i}{1 - \frac{a}{n}} = 5{\cdot}96$$

$$B: \frac{f}{1 + 4\frac{a}{n}} = 0{\cdot}0306, \quad \frac{\frac{1}{2} P_i}{1 + 4\frac{a}{n}} = 3{\cdot}30$$

$$C: \frac{f}{1 + 16\frac{a}{n}} = 0{\cdot}0240, \quad \frac{\frac{1}{4} P_i}{1 + 16\frac{a}{n}} = 1{\cdot}40.$$

The values of the armature constants agree very well for the proportion $\frac{a}{n}$ was (at rest) = 0·018, and we have accordingly for f:—

A	B	C
$f = 0{\cdot}0319$	$= 0{\cdot}032$	$= 0{\cdot}0310.$

The determination of the constants of the limbs is less accurate: A and C agree essentially, but B gives a decidedly higher value for P_i. For a more accurate decision the demagnetising magnitude, a, of the armature must be known; altogether the limb constant is that element which varies most readily, as it will be shown below.

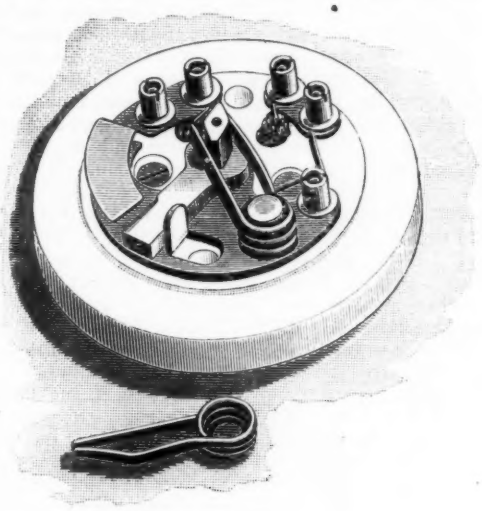
A consideration of the increasing resistance of the armature would probably have little effect on this result.

(*To be continued.*)

COMBINED SWITCH AND FUSE.

IN the making of switches, fuses, and lamp holders porcelain has several claims to preference over any other material, such as the fact that it is perfectly incombustible and its freedom from all tendency to the warping and twisting which sometimes happens with other materials when subjected to either heat or moisture. It can also be coloured and decorated to suit any requirement. Among its most strenuous advocates are Messrs. Dorman and Smith, who for a considerable time have almost exclusively used "pot" for these purposes. They have recently brought out new forms of their porcelain lamp-holder, the springs in which, while being of ample conductivity, are so arranged that they form a flexible support for the lamp without endangering the platinum loops. The lamps being used uncapped cannot shake out of their supports through the failure of the cement, and can be safely and easily placed in position without switching off the current. The arrangement of the combined switch and fuse is shown in the figure. The

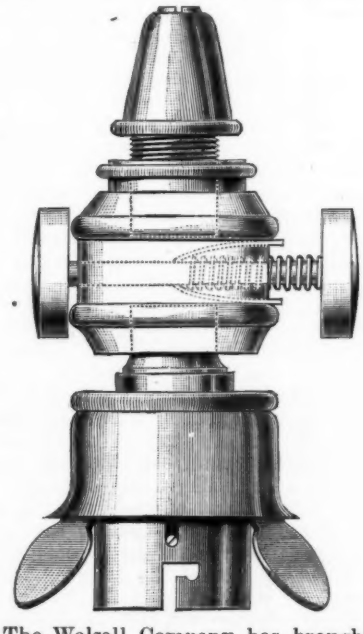
contact arm is constrained to remain in the "on" and "off" positions by a spring, which is so arranged that at the moment of breaking contact a strong couple is exerted, tending to carry the arm rapidly away to a safe and non-sparking distance. No arc can possibly form, and the spring is strong and of a peculiar form. The wires are easily coupled up, all connections being made on the face, a recess being left at the back of the



switch for leading in the wires. Provision is made in every switch for a safety fuse which can be easily replaced. The use of steel for the spring of these switches would in certain cases be found to be objectionable, especially in ship work, and we would suggest the substitution of German silver, which has been found in practice to be far preferable.

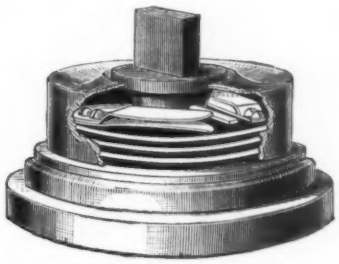
A NOVELTY IN SWITCHES.

THE want has long been felt of a handy switch to form part of, or to be easily attached to the lamp holder, both for hanging lamps and for use with brackets, in order to save the expense of running leads down to wall



switches. The Walsall Company has brought before our notice a switch well calculated to serve these purposes. The contact is made by a spring which is forced by the finger between the edges of two brass tubes and when fairly engaged is held in position by the notch; it is readily released by the finger pressing the other end of the spindle carrying the spring, while a spiral spring gives a rapid "fly off." The brass tubes are connected to one lead and the lamp respectively. As attached to a suspended holder it is at once seen that it requires only one hand to put the light on and off, and the advantages of this for lamps hanging only just within reach can readily be appreciated.

The arrangement is applicable to all lamp holders which have a central tube for screwing to brackets, &c., and through which the lead is meant to pass. As a saving of cost we should think that it will find a large general use.



A neat little switch with double spring contacts is also before us, the chief merits of which are its simplicity and neatness, while ensuring as good a contact as can be desired.

ON THE PYROMAGNETIC DYNAMO, A MACHINE FOR PRODUCING ELECTRICITY DIRECTLY FROM FUEL.*

By THOMAS A. EDISON.

THE production of electricity directly from coal is a problem which has occupied the closest attention of the ablest inventors for many years. Could the enormous energy latent in coal be made to appear as electric energy by means of a simple transforming apparatus which accomplishes its result with reasonable economy, it will be conceded, probably, that the mechanical methods of the entire world would be revolutionised thereby, and that another of those grand steps of progress would be taken, of which the nineteenth century so justly boasts.

The simple production of a potential difference by means of heat is as old as Seebeck and Melloni. The science of thermo-electricity thus originated has been developed by Becquerel, by Peltier, by Thomson and by Tait, and the thermo-batteries of Clamond and of Noë have found many important practical uses. The results already attained in these generators have stimulated research marvellously, and many investigators have believed that in this direction lay the philosopher's stone. Our fellow-member, Moses G. Farmer, worked long and assiduously in this field, producing, it is believed, the most satisfactory results, as regards economy, which have ever been obtained. But even these results were not very encouraging. He never succeeded in converting 1 per cent. of the energy of the coal into electric energy. Quite recently Lord Rayleigh has discussed with his well-known ability the law of efficiency of the thermo-battery from the standpoint of the second law of thermo-dynamics. And he concludes that for a copper-iron couple, working between the extreme limits of temperature possible for these metals, a conversion of not more than one three-hundredth part of the coal energy can be hoped for. While, therefore, as a heat engine the thermo-cell appears to follow precisely the law of Carnot, and hence may have a theoretical maximum efficiency equal to that of the reversible engine of this

* Read before the American Association for the Advancement of Science, New York, August, 1887.

eminent philosopher, yet in practice its efficiency falls very far below this theoretical maximum.

It therefore follows that if the result hoped for is to be attained at all it must obviously be looked for in some other direction than in that of the thermo-cell. In considering the matter, another line of investigation suggested itself to me, the results of which I have the honour now to submit to my fellow members of the physical section. It has long been known that the magnetism of the magnetic metals, and especially of iron, cobalt and nickel, is markedly affected by heat. According to Becquerel, nickel loses its power of being magnetised at 400°, iron at a cherry-red heat and cobalt at a white heat. Since, whenever, a magnetic field varies in strength in the vicinity of a conductor a current is generated in that conductor, it occurred to me that by placing an iron core in a magnetic circuit, and by varying the magnetisability of that core by varying its temperature, it would be possible to generate a current in a coil of wire surrounding this core. This idea constitutes the essential feature of the new generator, which, therefore, I have called a pyromagnetic generator of electricity.

The principle of utilising the variation of magnetisability by heat as the basis of electric machines, though clearly applicable to generators, was first applied to the construction of a simple form of heat engine which I have called a pyromagnetic motor. A description of this motor will help us to understand the generator subsequently constructed.

Suppose a permanent magnet having a bundle of small tubes made of thin iron placed between its poles and capable of rotation about an axis perpendicular to the plane of the magnet after the fashion of an armature. Suppose further, that by suitable means, such as a blast or a draught, hot air can be made to pass through these tubes so as to raise them to redness. Suppose that by a flat screen symmetrically placed across the face of this bundle of tubes, and covering one-half of them, access of the heated air to the tubes beneath it is prevented. Then it follows that if this screen be so adjusted that its ends are equidistant from the two legs of the magnet, the bundle of tubes will not rotate about the axis, since the cooler and magnetic portions of the tube-bundle (*i.e.*, those beneath the screen) will be equidistant from the poles and will be equally attracted on the two sides. But if the screen be turned about the axis of rotation so that one of its ends is nearer one of the poles and the other nearer the other, then rotation of the bundle will ensue, since the portion under the screen, which is cooler, and therefore magnetisable, is continually more strongly attracted than the other and heated portion. This device acts, therefore, as pyromagnetic motor, the heat now passing through the tubes in such a way as to produce a dissymmetry in the lines of force in the iron field, the rotation being due to the effort to make these symmetrical. The guard plate in this case has an action analogous to that of the commutator in an ordinary armature. The first experimental motor constructed on this principle was heated by means of two small Bunsen burners, arranged with an air blast, and it developed about 700 foot-pounds per minute. A second and larger motor is now about finished, which will weigh nearly 1,500 pounds, and is expected to develop about 3 horse-power. In both these machines electromagnets are used in place of permanent magnets, the current to energise them being derived from an external source. In the latter machine the air for the combustion is first forced through the tubes to aid in cooling them, and then goes in to the furnace at a high temperature.

The earliest experiments in the direction of the pyromagnetic production of electricity were made with a very simple apparatus, consisting of a charged electro-magnet, having a tube of thin iron passing through its cores near their outer ends, a coil of wire being wound around this tube, and including an ordinary sounder delicately adjusted in its circuit. The tube beneath the coil was covered with asbestos paper. After heating the tube to redness by a gas blast directed into it at one end, a jet of cold air was suddenly substituted for the flame, the sounder at once closed, showing that the change in the magnetisability of the iron had varied the distribution of the lines of force within the coil, and thus had produced a current of electricity in this closed circuit.

The construction of a machine of sufficient size to demonstrate the feasibility of producing continuous currents on the large scale in this way was at once begun and has only just been completed. The new machine consists of eight distinct elements, each the equivalent of the device already mentioned, consisting of the two legs of an electro-magnet somewhat far apart (12 inches actually), having at one end the ordinary yoke, and at the other a roll of corrugated sheet iron ·005 inch thick called an interstitial armature; this armature having a coil of wire wound upon it and separated from direct contact by means of asbestos paper. The eight elements are arranged radially about a common centre, and are equidistant, the eight interstitial armatures passing in fact through the iron discs, which constitute the common pole piece of all the electro-magnets. The coils wound upon the interstitial armatures are connected directly in series, the whole forming a closed circuit. Through the centre of these discs a hollow vertical shaft passes, carrying at its lower end a semi-circular plate of fire clay called a guard plate, which, when the shaft is turned, revolves close to the lower ends of the sheet iron armatures and screens off half of them from the access of heat from below. The shaft carries a cylinder of insulating material having metallic contact pieces let into it on opposite sides, the line joining them being parallel to the straight edge, of the guard plate. Upon this cylinder eight springs press, each of these springs being connected to the wire of the closed circuit above-mentioned midway between the coils. The length of the metallic segment is so proportioned that the following spring touches it just as the preceding one leaves it. The springs themselves are so adjusted that each of them comes into contact with its metallic segment just as the preceding coil of the pair to which it is connected is uncovered by the rotation of the guard plate. Upon the same shaft, and above the cylinder just mentioned, a pair of metallic rings are placed, insulated from the shaft, to each of which one of the metallic segments is connected. Brushes pressing upon these rings take off the current produced by the generator.

The entire machine now described is placed upon the top of any suitable furnace, fed by a blast, so that the products or combustion are forced up through those interstitial armatures which are not covered by the guard plate, and raise them to a high temperature. The field magnets, when charged, magnetise of course only those interstitial armatures which are cold, *i.e.*, those beneath the guard plate. On rotating this plate, the interstital armatures are successively uncovered on the one side and covered on the other; so that continually during the motion four of the eight armatures are losing heat and the other four are gaining heat. But those which are losing heat are gaining magnetism, and *vice versâ*. Hence, while currents are generated in all the armature coils, since in all the magnetism is varying, the current in the coils beneath the guard plate will be in one direction, while that in the coil exposed to the fire will be in the other. Moreover, whenever a armature passes out from under the guard plate, its condition at once changes; from losing heat and gaining magnetism it begins to gain heat and lose magnetism. Hence, at this instant, the current in its coil is reversed, and, consequently, the line connecting this coil with the one opposite to it constitutes the neutral line, or line of commutation, precisely as in the ordinary dynamo. Indeed, the action of the interstitial armature coils of the pyromagnetic dynamo resemble strongly that of the ordinary armature coils of the Gramme ring, not only in the manner of connecting them together, but also in their functions, the change of direction in the current as the magnetism of the field changes sign in the latter case, corresponding closely to the change of current in the former case, due to the direction of the temperature change. But

it will be observed that while in the Gramme ring the loops between the armature coils are connected to commutator segments equal in number to that of the coils, upon which commutator two brushes press, in the pyromagnetic dynamo the loops between the armature coils are connected to an equal number of brushes (in this case eight), while the commutator segments are only two in number; so that the functions of the commutator and the brushes in this generator are in a certain sense reversed as compared with the ordinary dynamo.

The potential difference developed by this dynamo will obviously depend (1) upon the number of turns of wire on the armature coils; (2) upon the temperature difference in working; (3) upon the rate of temperature variation, and (4) upon the proximity of the maximum point of effect. No advantage will be gained, of course, by raising the temperature of the interstitial armature above the point at which its magnetisability is practically zero; nor will it be advantageous on the other hand to cool it below the point where its magnetism is practically a maximum. The points of temperature, therefore, between which for any given magnetic metal it is most desirable to work, can be easily

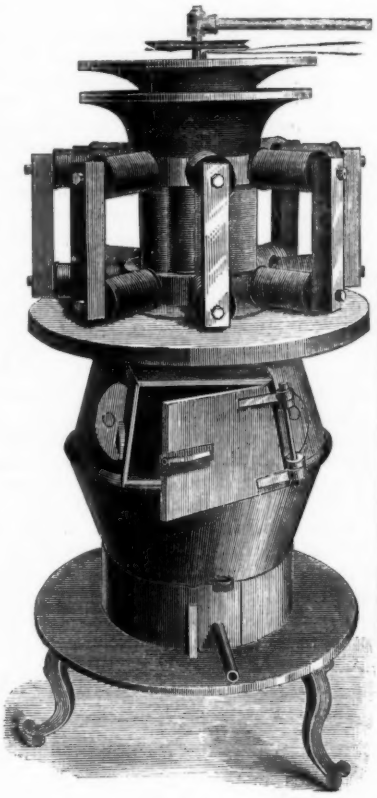
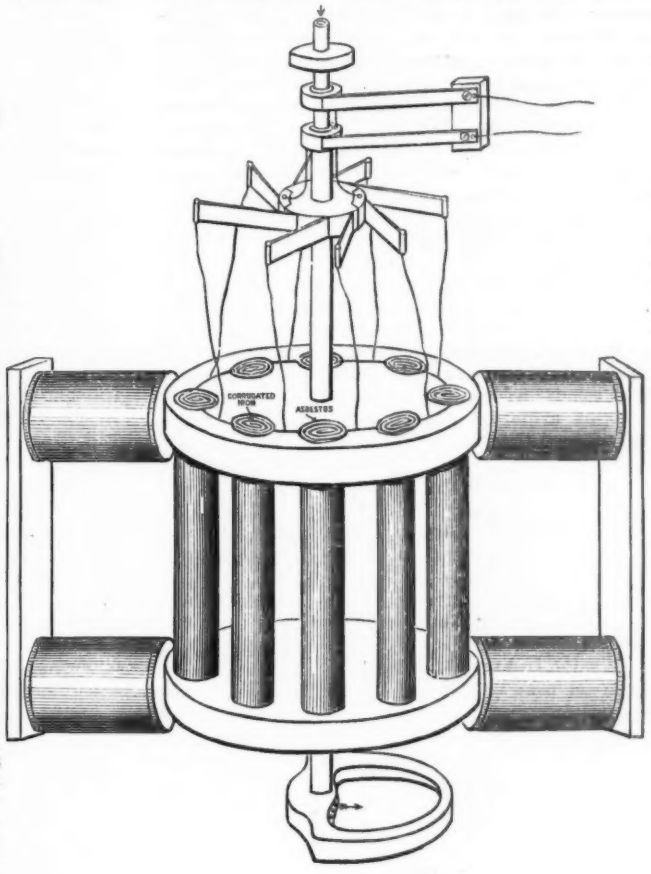


FIG. 1.



(*Reproduced from the "Electrical World."*) FIG. 2.

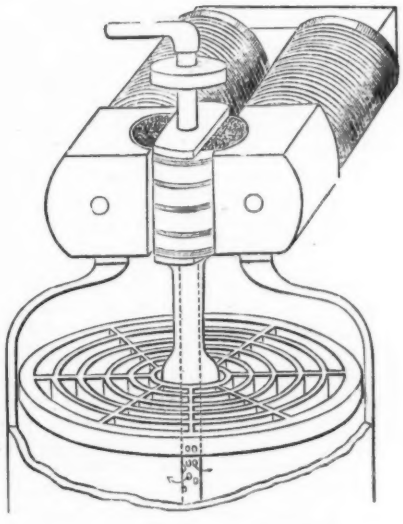
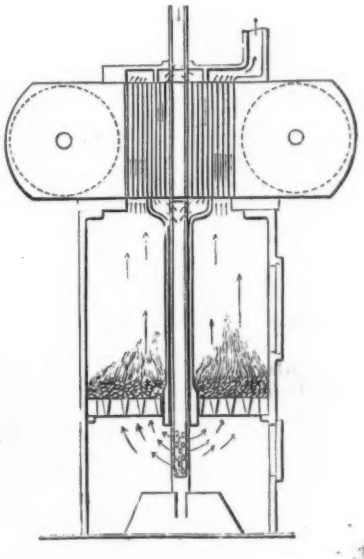


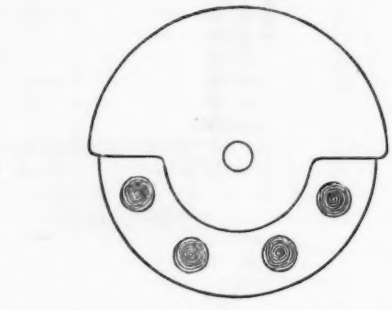
FIG. 5.



(*Reproduced from the "Electrical World."*) FIG. 6.

determined by an inspection of the curve showing the relations between heat and magnetism for this particular metal. Thus the points of temperature at which the magnetisability is practically zero, as above stated, are a white heat for cobalt, a bright red for iron and 400° for nickel. On the other hand, while at ordinary temperatures iron has a maximum intensity of magnetisation represented by 1,390, its intensity at 220° is 1,360; and hence no commercial advantage is gained by cooling the iron below this temperature. Nickel, however, whose maximum intensity of magnetisation at ordinary temperature is 800, has an intensity of only 380 at 220°. Hence, while this metal requires a lower maximum temperature it also requires a lower minimum one; but it may be worked with much less heat. The rate of the temperature variation is determined by the rapidity with which the guard plate revolves. And this in its turn is dependent upon the rapidity with which the interstitial armature can be cooled and heated. That it may take up and lose heat readily the sheet-iron of which it is made is very thin (only ·005 inch thick, even when its durability is increased by enamelling or nickelling); it is corrugated and rolled up so as to expose a large surface (about 60 square feet for the eight armatures), and hot and cold air are alternately forced through the armature. Experiments

FIG. 3.



(*Reproduced from the "Electrical World."*)

FIG. 4.

already made show that the guard plate can probably be made to revolve 120 times a minute. Since the potential difference is proportional to the number of lines of force cut per second, it is evident that by doubling the speed of rotation, twice as many lines of force would flow across the generating coils per second and the output of energy would be quadrupled. Exactly what thickness of metal is the most suitable for the purpose, what the relative volume occupied by metal and by air space in the interstitial armature should be, what is the best diameter for this armature, or even the best metal, what the best limits of temperature and what the best speed of rotation to produce the maximum potential difference—all these are questions which must be decided by experiments made upon the generator itself.

The results thus far obtained lead to the conclusion that the economy of production of electric energy from fuel by the pyromagnetic dynamo will be at least equal to and probably greater than that of any of the methods in present use. But the actual output of the dynamo will be less than that of an ordinary dynamo of the same weight. To furnish 30 sixteen-candle lights in a dwelling-house would probably require a pyromagnetic generator weighing two or three tons. Since, however, the new dynamo will not interfere with using the excess of energy of the coal for warming the house itself, and since there is no attendance required to keep it running, there would seem to be already a large field of usefulness for it. Moreover, by using the regenerative principle in connection with it, great improvement may be made in its capacity, and its practical utility may very probably equal the interesting scientific principles which it embodies.

[We reproduce on preceding pages the drawings exhibited at the meeting in explanation of the paper. Fig. 1 represents the pyromagnetic generator in perspective. Fig. 2 shows diagrammatically the manner in which the coils are connected with the commutator at the top and the manner in which they are built up. The cores of thin corrugated iron are held at the top and bottom by iron plates, which are magnetised by the surrounding electro-magnets. The corrugated cores, which allow the passage of the heated gases through them, are covered with asbestos and then wrapped with wire, the ends being joined in series, as shown, and the joints connected to the brushes instead of to the commutator. The air blast passes through the shaft from above and passes out from the apertures in the revolving plate of fire-clay below the tubes. Fig. 3 shows this plate, looking from below, from which it will be seen that four tubes are cooling, being screened from the heat, and also by means of the cold air blast, and four are being heated by the passage of the heated gases. Fig. 4 shows the plate resting upon the top of the stove. The pyromagnetic motor is shown in diagrammatic perspective in fig. 5 and in section in fig. 6. The armature, it will be seen, is built of small iron tubes, part of which placed obliquely to the lines joining the poles, are continually cooled and attracted by the poles, while the remainder are demagnetised by the heat.]

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

(*From the Special Correspondent of the "Electrical Review."*)

THE fifty-seventh annual meeting of what was once called "the Peripatetic Parliament of Science," in other words, the British Association for the Advancement of Science, has now come to an end. It has been a noteworthy meeting in many respects. From the purely scientific side it has been an eminent success, for although nothing startlingly new has been communicated, there have been recorded decided and important advances in more than one branch of scientific knowledge. To the physicist and the chemist, perhaps, the most important of all the papers were those put before Sections A and B, sitting jointly under the presidency of Sir William Thomson, on Saturday. These dealt with that interesting but hitherto rather vaguely known subject, electrolysis. Prof. Oliver Lodge has laboured strenuously to make this field a more open and better cultivated one, and he has gathered under his standard a number of truly scientific workers whose eminence indicate the importance to be attached to the new researches of which they were on Saturday the communicators and exponents.

A second reason for marking the Manchester meeting of 1887 as one a little out of the ordinary run was the presence of a large number—closely approaching one hundred—of foreign scientists, whose fame had preceded them. Profs. Wiedemann, Quincke and Weber from Germany, and Prof. Lippmann of Paris, each had something to communicate on physical questions, and all the English members were enthusiastic in the reception which they accorded their visitors. No less cordial was the greeting which was extended to the American men of science, of whom Prof. H. A. Rowland and Prof. C. A. Young took the most prominent part in the transactions of Section A.

What was not quite so satisfactory as the nature of the subjects discussed and the great gathering of re-

presentatives of international science was the weather. Up to only a day or so before the meeting was opened by the delivery of Sir Henry Roscoe's masterly address fine weather had prevailed in Manchester for months—too long, indeed, for the sanitary comfort of the inhabitants, for a great scarcity of water arose; but with the arrival of the city's distinguished visitors down came the rain as if to protest against anything but the closest application to serious work. The ladies, young and old, who look anxiously forward to the meetings of the British Association because they afford the opportunity for a little extra holiday-making and its attendant mild dissipation, were of course greatly put out (although it must be admitted that they bore the harsh disappointments which followed one another on each succeeding day with Spartan-like firmness and the utmost possible cheerfulness); but we should be inclined to doubt whether the rain had much influence—at any rate other than beneficial—upon the attendance at the sectional sittings. Towards the close of a long meeting the audience naturally gradually thinned down, but generally speaking there were fairly good audiences all round. Manchester has once more the proud consciousness that it has eclipsed all other towns and cities which the B. A. A. S. has visited, both in its attractiveness to strangers and in the number of resident members it has contributed; altogether it was a monster meeting, and one not soon to be forgotten, both for its pleasures and its disappointments. The excursions, to which the latter term has some application, did not fall through; a moderate number of enthusiasts (enthusiasts either in regard to sight-seeing or in the pursuit of geological or antiquarian investigations) was found ready to start on nearly every one of the prearranged expeditions.

To come back to the more important part of the proceedings, it will be interesting probably to give a *resumé* of the work done in the sections having peculiar interest for electricians and telegraph engineers. Beginning, then, with Section A and the first sitting on Wednesday last week, after the delivery of a humorous "Dynamical Parable" by the president, Sir R. S. Ball, F.R.S., who succeeded in entertaining if not in instructing his audience, Prof. A. Schuster, F.R.S., gave a brief description of some experiments which he has recently made, the results of which he has already communicated to the Royal Society, on the conduction of electricity through gases. It is known that a very large E.M.F. is required to send a current of any sort through a gas, but Prof. Schuster found that by sending a current of large E.M.F. through one part of a vessel containing a gas a current of small E.M.F. might readily be sent through any other part. To give a clear idea of his experiments, he employed a large vessel divided into two equal parts by a metallic screen. On one side and near the screen were placed two electrodes in connection with a battery of a thousand bichromate cells. On the other side of the vessel were two other electrodes connected with the poles of one Leclanché cell; a fraction of the current from a Leclanché cell even was sufficient. As soon as a current was transmitted through the gas in the vessel from the large battery a measurable current was sent through from the small battery. At the same meeting Prof. Lamb, F.R.S., read a paper "On the Theory of Electrical Endosmose and Allied Phenomena, and on the Existence of a Sliding Coefficient for a Fluid in Contact with a Solid," and a very interesting paper was communicated by Prof. Stroud, D.Sc., and Mr. W. H. Haldane Gee, B.Sc., "On a Null Method in Electro-Calorimetry." These will be fully dealt with in the REVIEW at the proper time.

On Friday, the second day in the sections, Sir William Thomson held the strongly interested attention of the members of Section A for a considerable portion of the morning, whilst he exhibited and explained his new standard electric balances, which have already been described in the REVIEW. Prof. Ewing, F.R.S., and Mr. W. Low contributed papers on the magnetisation of iron and steel. The steel subject was the manganese specimen prepared by Hadfield, of Sheffield, which has been found to be almost non-magnetisable. Prof. Barrett's name was down for a paper on the physical properties of the same variety of steel, but there was not sufficient time left to take it on Friday, so it, and the discussion upon Prof. Ewing's paper, were postponed till the following Tuesday.

Saturday was devoted, as stated earlier, to a joint discussion by the physical and chemical sections on electrolysis. Prof. Lodge opened the subject with a report of the standing committee which has been working under his direction for the past two or three years. This report was so exhaustive as to call forth from Sir William Thomson the high praise that it was the *beau ideal* of what a report should be. Nothing that could be suggested had been omitted, and everything that had received notice had been dealt with in the most unexceptionable manner. Prof. G. Wiedemann addressed the meeting upon some points in electrolysis and electric conduction; Prof. G. F. Fitzgerald, F.R.S., read a paper on the accuracy of Ohm's law in electrolytes; Prof. S. P. Thompson communicated some researches by Helmholtz concerning the electrolysis of water; Prof. W. C. Roberts-Austen described some experiments on the possible electrolytic decomposition of alloys, the effect of which was to accentuate the negative results obtained by other investigators; Prof. Oliver Lodge gave the result of his experiments on the speeds of ions; Prof. H. A. Rowland made a communication upon chemical action in a magnetic field; Dr. J. H. Gladstone read a paper on the action of an electric current in hastening the formation of lagging compounds; Prof. S. P. Thompson gave some new and important imformation with regard to the electro-deposition of alloys and on the industrial electro-deposition of platinum; Messrs. W. W. Haldane Gee, H. Holden, and C. H. Lees described some novel results which they had obtained in their investigations in electrolysis and electrolytic polarisation; a paper was read by Mr. W. N. Shaw for Mr. T. C. Fitzpatrick on the action of the solvent in electrolytic conduction; and papers by Prof. M'Leod and Mr. W. Langley on the electrolysis of a solution of ammonic sulphate, and on a probable manifestation of chemical attraction as a mechanical stress, were taken as read. All these papers, as we have before mentioned, related to the work of the Electrolysis Committee, and they are to be carefully edited before being published.

On Monday Section A abjured electrical subjects for the time, and electrical interest centred in Section G, where, under the presidency of Prof. Osborne Reynolds, applications of electricity received attention. Mr. W. H. Preece gave his periodical report of progress in Post Office telegraphy, a subject with which no one is more competent to deal. One of his papers was on copper wire, and a second on fast speed telegraphy, and genuine applause greeted his statement that whereas in 1870 the greatest speed attainable was 80 words per minute, 600 words per minute is the rate at which messages are now sent. Prof. George Forbes, who has a habit of working quietly all the year through and coming out with a surprise at the end of it, this time had two new things to show, a system of gas pipe conduits for underground electrical distribution, a subject which he has made his own, and a marvellously beautiful current meter, which excited the admiration and wonder of such men as Sir William Thomson, Prof. Perry and Prof. Silvanus Thompson. It is much to be hoped that an opportunity will soon offer for the practical commercial employment of Prof. Forbes's meter—or some other. Mr. Gisbert Kapp and Messrs. C. H. W. Biggs and W. H. Snell contributed papers on dynamos—maximum work and alternate currents; and Mr. F. R. Upton described the telemeter system of Mr. C. L. Clarke, which seems to create still another useful application for electricity. The discussions on most of these papers possessed much greater value than B.A. discussions usually do; platitudes were fewer, and were accompanied by intelligent and detailed criticism. In fact, the meeting was of a character once more to suggest the value of frequent similar gatherings of practical electricians.

Tuesday was a busy day in Section A. Prof. Quincke explained the results of his researches upon the magnetic properties of gases, and this was followed by important papers by Mr. R. T. Glazebrook and Prof. H. A. Rowland, and ensuing discussions, upon the B.A. standards; Prof. Rowland dealing with the final value of the B.A. unit of electrical resistance as determined by the American Committee, of which he was a member. Mr. Preece read a paper upon the resistance of commercial iron, another upon electric induction between wires and wires (supplementary to his paper on the same subject last year), and a third on the coefficient of self-induction in telegraph wires. Prof. Ewing brought forward a further contribution to the subject of magnetisation of iron, his paper dealing with the influence of a plane of transverse section on the magnetic permeability of iron. Prof. Barrett's postponed paper on manganese steel was read, and Sir William Thomson, alluding to it, remarked that if several important "if's" were capable of being got over, a complete revolution in the plating of ships would result from the discovery of the properties of this curious metal. Sir William Thomson once more brought forward his centiampère and deciampère balance, and explained how it might be applied to the measurement of the E.M.F. of a single cell. Lord Rayleigh fancied he should feel inclined to test the accuracy of Sir William Thomson's instrument by means of a Clark's cell rather than to measure the E.M.F. of the cell by the balance. Sir William rejoined that probably Lord Rayleigh resorted in the end to electrolysis for the standardising of his Clark's cells, and it was upon electrolysis that his instrument was based. The theory of dynamos and practical questions relating to their action received attention at the hands of Dr. E. Hopkinson and Mr. A. P. Trotter. The former enunciated a general theory of dynamos, and the latter read a paper on the production of a constant current with varying E.M.F. from a dynamo.

At the extra sitting of the section on Wednesday, Mr. J. Swinburne dealt with a subject which he has exhaustively treated in our own columns, namely, electrical measuring instruments, his paper being upon compensation of measuring instruments for temperature errors. Mr. Vernon Harcourt showed his new standard pentane lamp, Mr. Haldane Gee described a comparison magnetometer, and Mr. J. T. Bottomley read a paper on the expansion by heat of wires under pulling stress. Several of the papers read during the meeting follow: others will be published in future issues.

A NULL METHOD IN ELECTRO-CALORIMETRY.

By Prof. W. STROUD, D.Sc., B.A., and W. W. HALDANE GEE, B.Sc.

(Section A.—Mathematical and Physical Science.)

Thursday, September 1st, 1887.

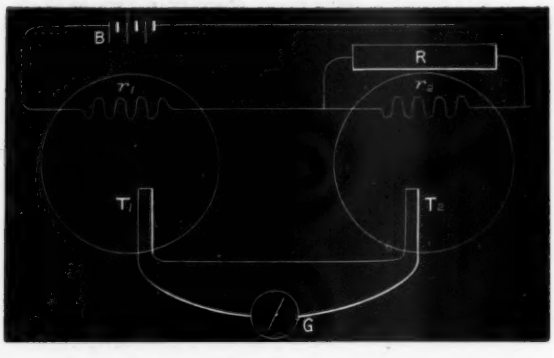
THE idea of introducing heat into a calorimeter by means of an electric current traversing a wire, has been utilised by some physicists for the measurement of the specific heat of liquids. The method employed by Pfaundler consisted in using two identical calorimeters, the one containing water, the other the liquid to be experimented upon. A current was passed through two spirals of wire of equal resistance, the one immersed in one calorimeter, the other in the second. A thermometer in each calorimeter served to measure the rise in temperature. The advantages of heating a liquid in a calorimeter electrically are manifest. Experience with Pfaundler's method both at Owen's College and at Yorkshire College suggested to us independently the possibility of modifying the arrangement so as to obtain a null method.

We realised that a great improvement would be effected by altering the ratio of the strengths of the currents in the two calorimeters in such a way that the same rise in temperature takes place in each, which can be indicated by some form of differential thermometer or thermo-electric combination. We thereby secure not only all the advantages of a null method, but further, the correction for radiation becomes a matter of secondary importance.

The apparatus which is exhibited before the association consists of two equal calorimeters provided with stirrers rotated by clockwork. A thermo-electric pile consisting of 10 iron-German-silver junctions in circuit with a suitable galvanometer is used as the differential thermometer.

Instead of this we have also employed the following method in which a Wheatstone bridge or rheostat is used.

The thermo-electric arrangement was such that a difference of temperature of $\frac{1}{100}$th of a degree centigrade could be detected. During the adjustment of the resistances in the progress of a determination, the calorimeters are continually rising in temperature. To bring them back to the temperature of the air, the



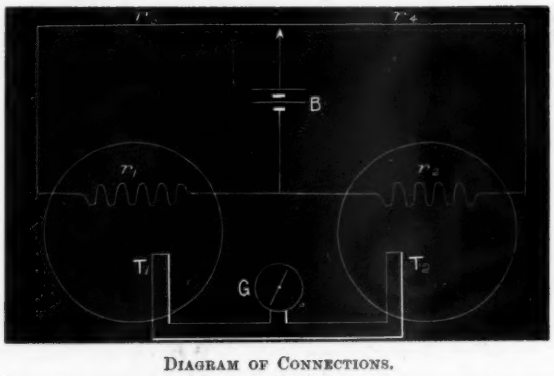
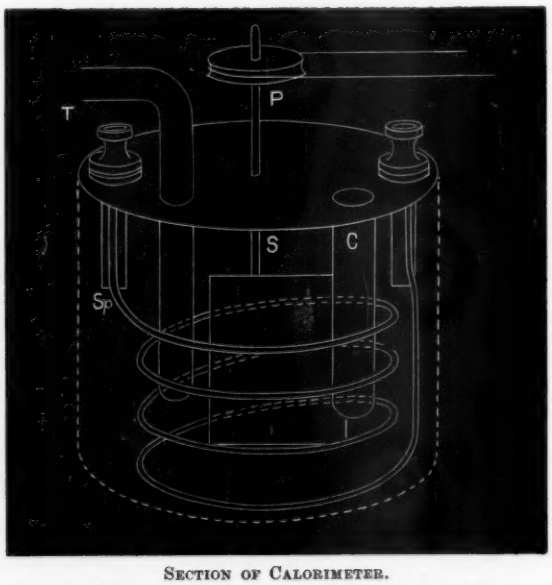


DIAGRAM OF CONNECTIONS.

B, secondary battery; r_1, r_2, resistances in calorimeters; R, resistance box whose terminals are joined to the ends of the resistance, r_3, so as to act as a variable shunt; T_1, T_2, thermo-electric junctions in circuit with galvanometer, G.

following process of cooling has been adopted. Within each calorimeter there is a water-tight cylinder of thin sheet copper. When the apparatus is required to be cooled, we introduce into each of these a leaden tube conveying a current of water. This is shown in the fig.



SECTION OF CALORIMETER.

Sp, spiral of German silver wire; S, stirrer worked by clockwork by means of pulley, P; T, thermo-electric junction; C, hollow cylinder for cooling purposes.

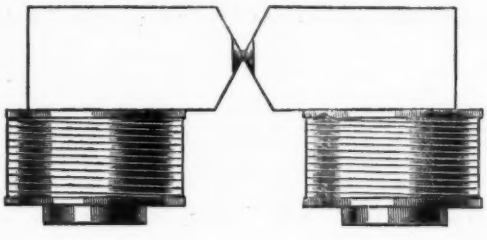
The method which manifestly possesses many theoretical merits we have found in practice to be susceptible of considerable accuracy. In conclusion, we may remark that the application of similar electrical methods to the determination of other calorimetrical questions, such as the latent heat of vaporisation of liquids might with advantage be extended.

ON THE MAGNETISATION OF IRON IN STRONG FIELDS.

By Professor J. A. EWING, B.Sc., F.R.S., and WILLIAM LOW.

(Section A.—Mathematical and Physical Science.)
Friday, September 2nd, 1887.

IN March of the present year we communicated to the Royal Society ("Proceedings," vol. xlii., p. 200), the results of experiments on this subject, in which the magnetism of a narrow neck or isthmus of iron placed between the pole-pieces of a large electro-magnet was examined, by suddenly drawing out the piece, or turning it end for end so that the direction of its magnetisation was reversed. The piece examined was in the form of a bobbin with a short central neck, turned to a small diameter and with large spreading conical ends, which were in contact with the pole-pieces and provided an easy path for the lines of induction to converge to the central neck. The metal of the neck was in this way subjected to a much greater magnetic force than it would be practicable to produce by the direct action of a magnetising solenoid. The induction in the iron was measured ballistically by means of a coil of fine wire, in a single layer, round the iron neck. The magnetic force in the air space closely contiguous to the neck was also measured by means of a second or outer induction coil, of a slightly greater diameter than the inner one. This determination of the field allowed a correction to be applied for the air space enclosed by the inner coil, and it also gave what was probably a close approximation to the value of the magnetic force within the metal itself.



The object of the present note is to describe shortly the results of further experiments of the same kind, the details of which may be reserved for subsequent publication.

In the former experiments an electro-magnet with pole-pieces 5¼ cms. square was used. The conical ends of the bobbins tested brought the central neck down to a diameter of 0·65 cm. in one form of sample and 0·923 cm. in another form. With this we succeeded in forcing the induction $\mathfrak{B}$ in Lowmoor and Swedish wrought iron up to values lying between 32,000 and 33,000 C.G.S. units, the strength of the magnetic field in the air close to the neck being then about 11,000 C.G.S. units.

Large as those values were, they have been greatly exceeded in the present series of experiments. In the former paper we pointed out that the magnetic induction of the iron examined showed no sign of approaching a maximum, and that the value to which it might be forced by the "isthmus" method depended on the scale of the experiments. Through the kindness of Professor Tait in allowing the large electro-magnet of the Edinburgh University Laboratory to be brought to Dundee, we have now been able to subject iron to much higher magnetising forces, and to secure a much greater concentration of the lines of induction. The Edinburgh magnet is one of exceptional power. Its limbs, which are vertical, are about 60 cms. long, and the cores are 10·7 cms. in diameter. Rectangular blocks of soft wrought iron 9·6 cms. square serve for pole-pieces. To allow the old bobbins to be effectively used we added a pair of conical intermediate pieces of soft iron, which virtually formed an extension of the conical ends of the bobbin. Between these the bobbin was placed, the form generally used being that described in the previous paper as sample A. The neck of this sample had originally a diameter of 0·923 cm., and consequently a section of 0·669 square cm., or about $\frac{1}{10}$th that of the pole-pieces. As in the former experiments, the highest values of magnetism have been reached with Lowmoor iron, and nearly as high values with Swedish iron.

The same Lowmoor bobbin that had been formerly used (sample A) had its magnetism measured by withdrawing it from the field, while the magnet with all its numerous coils in series was excited by a current which ranged up to 40 ampères. At the highest value the induction $\mathfrak{B}$ in the neck was 38,000 C.G.S., and the outside field, close to the neck, was 18,900 C.G.S. A Swedish sample of the same shape gave an induction of 37,620 with a field of about the same force.

To push the induction to still higher values the Lowmoor sample was then turned down in the central neck until the diameter was reduced to 0·397 cm. This made its section only $\frac{1}{17}$th of the section of the pole-pieces. Careful determinations, several times repeated, then gave for the highest induction the enormous value 43,500 C.G.S., the outside field being 25,620 C.G.S. Here, as in the other figures already given, the induction stated is that which is found after the air space enclosed by the inner coil is allowed for, and after a suitable allowance is made for the residual magnetism of the piece. The residual induction is only about 500 C.G.S. units.

The ratio $\frac{\mathfrak{B}}{\text{outside field}}$ in this extreme case is 1·7, and the quantity $\frac{\mathfrak{B} - \text{outside field}}{4\pi}$, which would be the intensity of magnetism $\mathfrak{J}$ if the magnetic force within the metal were identical in value with the outside field, is 1,420. In the former experiments this quantity had values which decreased from 1,680 to 1,620, while the induction increased from about 25,000 to 32,000; here, with an induction of 43,500, it has fallen off to a much more marked extent. We cannot yet speak with any certainty as to the degree of approximation of this quantity to the intensity of magnetism, $\mathfrak{J}$; unless, however, the mean magnetic force within the neck is much less than the force at the surface, the results show that $\mathfrak{J}$ is becoming less as the induction is being forced to these extreme values—in other words, that the iron is tending towards demagnetism in the manner Weber's theory leads us to expect. The question is one of the greatest interest, and we are now endeavouring to obtain a better knowledge of the magnetic force within the metal by examining the variation of the force at short distances from the surface of the neck.

A final effort was made to force the induction in Lowmoor iron to higher values, by turning the central neck down still further, until its section was less than $\frac{1}{1200}$th of the section of the pole-pieces, and annealing the bobbin carefully before magnetising it. The value of $\mathfrak{B}$ then reached was 45,350 C.G.S. units, which is the greatest induction recorded in any of our experiments.

With cast iron the induction has been forced to 31,270 C.G.S., by applying a magnetic force of 16,900.

DISCUSSION.

Lord RAYLEIGH, being called upon by the President, said he had had no experience himself in this interesting subject of induction of very high forces. The interest of it was apparent to all, and until they knew pretty definitely what did happen at the end of the curve, it was obvious that speculations as to the nature of magnetism were very largely premature. He hoped Prof. Rowland would give his opinions upon the matter.

Prof. ROWLAND: When I first made experiments on this subject I was troubled, as Prof. Ewing says, by a little curvature at the end. I experimented with rings of iron, and I attributed the curvature to the non-homogeneity of the iron. I turned off the offside of the ring, which had been forged originally, and then I turned off some more, and eventually I found that to some extent this curvature at the end disappeared. Therefore I attributed the whole curvature to the cause I have stated. However, my experiments were not sufficient to establish whether there was a maximum for the magnetic induction and for the intensity of the magnetisation. I should say from these experiments that there would be a very decided maximum for the intensity of magnetisation. When one subtracts the intensity of the field from the magnetic induction the results are very similar, and as Prof. Ewing has remarked, they often decrease in value. I suppose the decrease may be due possibly to an error in the experiments. I think they show a decided maximum of magnetism at a higher value than that I gave, but the maximum is for the intensity of magnetisation and not for the magnetic induction. In that case I do not see any reason why this curvature at the end should not be due to the original cause which I gave, which is want of homogeneity in the iron. There may be some particles in the original iron which do not attain their full power at once, and require a very strong field to magnetise them, and one can see very readily if one had a mixture of steel and soft iron that it would give a curve of this nature. I am not at all convinced but that the curving is something very similar to that I recently gave.

Prof. EWING: I ought to have said with regard to the question of whether this quantity has really passed a maximum and is coming down, that it will require the field to be inaccurate to an extent of at least 12 per cent. to make the quantity really constant instead of apparently a descending one as we have it here. That is to say, the field in the last set of experiments would require to have been 22,000 instead of 25,000 in order to make this quantity constant. I do not myself quite understand why the want of homogeneity in iron should make it possible to get an induction of 45,000 C.G.S. units into it when a piece of pure iron stops at 25,000.

ON THE MAGNETISATION OF HADFIELD'S MANGANESE STEEL IN STRONG FIELDS.

By Prof. EWING, F.R.S., and Mr. W. LOW.

(Section A.—Mathematical and Physical Science.)
Friday, September 2nd.

Messrs. Hadfield, of Sheffield, manufacture a steel containing about 12 per cent. of manganese and 0·8 per cent. of carbon, which possesses many remarkable qualities. Prominent amongst these, as the experiments of Hopkinson, Bottomley, and Barrett have shown, is a singular absence of magnetic susceptibility. Hopkinson, by applying a magnetic force, $\mathfrak{H}$, of 244 C.G.S. units to a specimen of this metal produced a magnetic induction, $\mathfrak{B}$, of only 310 C.G.S. units; in other words, the permeability μ was 1·27 and the intensity of magnetisation, $\mathfrak{J}$, was a little over 5 units. We are indebted to him for the suggestion that it would be interesting to apply to this metal the "isthmus" method of magnetisation (the results of which, as applied to wrought iron and cast iron, have been described in a former paper), with the view of seeing whether the magnetic resistance of manganese steel could be broken down by applying a very strong magnetising force.

Messrs. Hadfield were kind enough to supply a sample of the metal for experiment, out of which a bobbin was turned, with some difficulty, of a form resembling those used in testing wrought iron and cast iron, but with a wider central neck. The bobbin was magnetised by placing it between the pole-pieces of Prof. Tait's large magnet; and the induction within the neck, and also the field in the air immediately surrounding the neck, were measured in the usual way, by the help of two induction coils and by drawing the bobbin suddenly out from between the magnet poles. A large number of readings were taken, while the field magnet was excited with currents ranging from about 1 to 40 ampères. These gave values of the magnetic field (in the air immediately surrounding the central neck of the steel bobbin) ranging up to 5,200 C.G.S. units, and values of the induction, $\mathfrak{B}$, within the neck ranging up to 7,700 C.G.S. units. To be more exact, these latter were the values of that part of the induction which disappeared when the metal was drawn out of the field, but the correction for residual magnetism was probably negligible. The ratio of induction to field had a nearly constant value when the field ranged from about 1,000 C.G.S. to 5,200 C.G.S.; the values of this ratio, calculated from the observations, fluctuate somewhat, but do not appear to undergo any progressive change. The mean value of $\frac{\mathfrak{B}}{\text{outside field}}$ is 1·45, a quantity which we may probably take without substantial error as the value of the permeability, .

To test the influence of still stronger magnetic fields, a second series of experiments was made with a composite bobbin made up of a cylindrical shank, extending from end to end, of manganese steel, and conical pole pieces of soft wrought iron forced on to the steel shank so as to leave only a short length of it (about 3 millimeters) bare in the middle. With a given current in the field magnets, this gave much higher values of the field and the induction in the central neck, because the wrought iron cones now substituted for the conical ends of the solid steel bobbin that had been formerly used gave an easier path for the lines of induction to converge to the central neck. The field now ranged up to values slightly exceeding 10,000 C.G.S. units, and the highest induction reached was about 15,000 C.G.S. units. In this series of experiments, as in the former series, the ratio of induction to field fluctuated irregularly; but its mean value was nearly identical with the former mean, namely, 1·46. The intensity of magnetisation, $\mathfrak{I}$, was forced up to values lying between 300 and 400 C.G.S.

The experiments make it clear that even under magnetic forces extending to 10,000 C.G.S. units the resistance which this manganese steel offers to being magnetised suffers no breakdown in any way comparable to that which occurs in wrought iron, cast iron, or ordinary steel at a very early stage in the magnetising process. On the contrary, the permeability is approximately constant under large and small forces.

The conclusion had some practical interest. It has been suggested that this steel should be used for the bed-plates of dynamos and in other situations where a metal is wanted that will not divert the lines of induction from neighbouring spaces. In such cases the magnetic forces to which manganese steel would be subjected would certainly lie below the limit to which the force has been raised in these experiments. We may therefore conclude that in these uses of the material, it may be counted upon to exhibit a magnetic permeability only fractionally greater than that of copper, or brass, or air.

A NEW FORM OF SECONDARY BATTERY.*

By KILLINGWORTH HEDGES, Mem. Inst. Civil Engineers.

(Section G.—Mechanical Science.—Monday, September 5th.)

SECONDARY batteries or accumulators may be said to have become a necessity in private installations of the electric light, and to be as far advanced as any other part of the lighting system. The batteries which are best known are widely different from those designed by the original inventor, M. Gustave Planté, very little attention having been paid to this type until the matter was taken in hand by a French engineer, M. Phillimond Bailly, whose invention I shall have the honour of describing to you to-day. The battery, which has been termed the Phœnix, is of two kinds, Pb-Pb, or lead-lead, and Pb-Zn or lead-zinc, and it is to the latter to which I will confine my remarks. The idea of using zinc for the cathode or positive plate of a secondary battery is not new in principle, having been described by several inventors, but its adoption for commercial work was not practicable until about a year ago, when M. Bailly introduced this battery in several installations abroad, where they are still employed. M. Reynier had previously designed a battery with a lead or copper plate coated with zinc, but it failed, and long before this Mr. Swinburne tried a similar plan, employing oxide or carbonate of zinc; but both these arrangements were far more expensive than that of M. Bailly, who prepares his zincs by moulding zinc filings with mercury, and compressing it into a rod or plate.

In a lead-zinc battery the action is as follows:—The zinc plate is attacked by the sulphuric acid in the presence of the peroxide of lead, the latter acting as a perfect depolariser; consequently the reaction is much more energetic than in a lead-lead battery, and the available E.M.F. is, in fact, 2·5 volts, falling to 2·33 when current is taken out. A lead-zinc accumulator is, in fact, a perfect primary battery, in addition to having a large storage capacity, which M. Bailly has found to be five times as much as a lead-lead battery with plates of similar surface. In discharging, the zinc plate dissolves in the dilute acid, forming sulphate of zinc, which is decomposed on recharging, pure metallic zinc being deposited on the zinc plate. The zinc, if properly amalgamated, is thus never consumed, but only dissolved and re-deposited. I have on the table some zinc plates which have been used in a small portable battery which I have used nearly every evening for the past four months, and they are still quite fit for work, although they are simple strips of commercial zinc, and not made on M. Bailly's plan of moulded filings. If the latter is employed I do not see why the zinc plate should not last as long as the peroxide plate. The lead plates of the Planté cell were simple sheets of rolled up lead, and had very little capacity. In the Phœnix battery they are formed of a quantity of fine shreds termed "lead wool," which are interwoven among a number of strips or fringes cut out of a lead plate, so as to form a sort of basket work, which is submitted to pressure, and then placed in the space left between a porous pot and the outside receptacle. The object has been to have a solid metallic conductor permeating the whole mass of the lead wool, so as to pick up the current with a minimum loss due to internal resistance, which has been the cause of failure of those Planté batteries in which lead wool or spongy lead was employed. M. Bailly compares his mode of picking up the current to the "venous system of the human body," in that the main conductor or artery spreads out in every direction much in the same manner as the veins in the body. The capacity of lead plates constructed in this manner is very large, the lead wool giving a surface of 1·5 square metre per kilogramme of lead; every part of the mass is permeated by the fringe-like extensions of the conductor, which, being of much larger section than the lead wool filaments, remain firm and solid when the latter are completely peroxidised.

Lead-zinc batteries may be constructed in various forms; a convenient arrangement is the circular form which I designed with a view to strength and portability.

The zinc plate is contained in a circular porous pot, conical at the bottom so as to economise the mercury, which forms an excellent electrical connection between the copper conductors and the zinc, without the use of a soldered joint, and admits of the speedy removal of the zinc plate. In larger cells a flat zinc electrode is used, and is contained between two porous plates which are made of compressed sand and offer very little resistance to the current, because they are honeycombed in every direction, and are, in fact, too porous for primary batteries.

The outside case is made of celluloid, a material which is extremely useful for electrical purposes, in that it is unaffected by acid and can be readily moulded into any required shape; also it is much lighter than any other suitable material. For small cells I usually protect the celluloid by a wicker-work covering, but in the larger kind, when they have to be removed for charging, a very light and strong receptacle is made by placing the celluloid in a loose fitting wooden box, and running an insulating material between the two, which effectually takes off any jar that might injure the interior cell. I have found that the most suitable material is a compound known as Phœnix varnish, in that it is almost as cheap as pitch and does not shrink or crack at a low temperature.

A disadvantage attending the use of a lead-zinc battery has been often quoted, namely, that there is a greater fall of electromotive force than with a lead-lead couple. This is not a serious objection, even for lighting purposes, if the discharge is not pushed too rapidly; for driving motors, electrical welding, and other new methods to which secondary batteries may be applied, a fall of electromotive force is of little consequence, and is more than compensated for by the gain of nearly 25 per cent. in the E.M.F. M. Bailly states that he has obtained an output of nearly five times as much from a lead-zinc battery of similar surface to a lead-lead without lowering the E.M.F. below two volts; he has also obtained 28 ampère-hours per kilogramme of peroxidised plate, or 0·08 lb. per ampère-hour. In practice I have not obtained so good a result, the average output being 0·13 lb. per ampère-hour, which, however, compares very favourably with other batteries.

In the early days of accumulators it was seriously proposed to distribute electricity by their use in the same manner as milk. The all-important factor of the difference in weight of the empty milk cans—as compared with the empty batteries—was apparently forgotten, and the public quickly found this out, although there is a story that a railway company were satisfied with the statement that a set of batteries were empty, and, therefore charged the carriage at the returned empty rate.

It would not, however, be impracticable for a few people living in the same neighbourhood to arrange to take a supply of electricity for lighting their principal rooms, as a small set of batteries on the plan I have here could be easily delivered.

This basket contains six cells or bottles, the total weight being under 1 cwt., so that the whole can be carried by one man. The capacity of each cell is 60 ampère hours, and a sufficient number of lamps can be maintained to light a dinner table.

There is a great want at the present time for a small portable battery for railway carriage lighting, to be used as a reservoir for maintaining the lamps when the carriages are uncoupled for the purpose of making up the train. The successful illumination of railway trains by electricity has been practically demonstrated by the North-Western and other companies, who have had trains electrically lighted for some years. The plan which appears to give the best results is to fix a small dynamo and high speed engine either on the locomotive or back of the tender, giving the driver control of the apparatus, so that he can readily start it from the foot plate. The only objection has been the impossibility of disconnecting the carriages without extinguishing the

* Taken as read.

light. A battery on the plan I have described would not occupy more space than the receiver which is usually employed with the oil gas system, and would be far safer in every way.

The immunity from accident on our well managed railways is probably the reason that some fearful disaster has not before this attended the use of compressed gas. Railway passengers are ignorant of the dangerous nature of the illuminant, which is generally stored in steel cylinders under the carriages, although these cylinders are amply strong enough to resist the enormous pressure of the gas, but would be easily perforated in the event of a collision, with the result that the liberated gas mixing with air would either explode or in all human probability cause a dangerous fire.

If such an accident occurred in a tunnel—for instance, on the Underground Railway, where the system is generally adopted—there is the additional danger of suffocation from the escaping gas, which would occupy a very large volume of space. An accident took place quite recently on the Berlin Potsdam Railway which ought to act as a warning. An empty goods train ran into a passenger train, piercing the gas cylinder. The liberated gas, being set on fire by the goods engine, flew about in all directions, setting fire to everything in the carriage, in which there were three persons, who, before they could escape, were burnt to cinders. It is stated in the official account that the only remnant of the male passenger was "the buttons on his waistcoat." The gas receiver was a long sheet iron drum placed transversely under a second class carriage.

It is needless to say that with electric light no such accident could happen, and as the employment of the compressed gas appears to offer the chance of either "cremation or suffocation," it would be far better for the railway companies to improve their existing oil lamp system until they can see their way to universally adopt the electric light.

UNDERGROUND ELECTRICAL CONDUCTORS.

By Prof. GEORGE FORBES, F.R.S.

(Section G.—Mechanical Science.—September 5th, 1887.)

THE author has designed the proposed system to fulfil several important conditions:—

1. The conductors and their insulation should be economical in construction.
2. They should be protected from injury by a trough or casing.
3. This trough should be of small cost and its merits must have been well tested.
4. The trough must be capable of carrying conductors at several different potentials.
5. It must be possible gradually to add to the conductors as the consumption of electricity in a district increases.
6. An easy means must be provided for taking branches from the mains into houses.
7. An easy means must be provided for leading the conductors round gas and water pipes and other obstacles.

The first condition can best be secured by having bare copper wire conductors and air insulation.

The second and third conditions by using ordinary cast iron gas pipes, whose qualities are thoroughly well known and whose laying and repairing and keeping water-tight is every-day work in every town in the country.

The fourth condition is attained by having porcelain insulating discs, two in each cast iron pipe. Each insulator has as many holes through it as there are different potentials to be maintained. These porcelain discs are supported on the iron pipes only at a few points, the intervening spaces allowing drainage in the cast iron pipes, and also permitting dry air to be forced through a system of pipes.

The fifth and sixth conditions are attained by the special peculiarity of this invention, which consists in using thin split copper tubes with a quarter-inch gap at the split. These are each six inches longer than one of the iron pipes. By pinching the end of one of these tubes and inserting it into the end of another, and continuing the process, a long continuous tube can be made for carrying the bare copper wire conductors. These continuous tubes pass through the holes in the insulators. The number of copper wires can be added to as the requirements of a district increase. When two-thirds full, these wires are all withdrawn and a bare wire cable filling the whole space of the tubes is drawn through. The wires are drawn through from manhole to manhole. A manhole is placed at each corner of a street; and serves also as a sump for pumping out accumulations of water. When it is required to connect a house to the mains, the iron pipe is drilled and tapped with a one-inch hole. Insulated wires are soldered to the copper tubes of the required potentials, and are led to the houses through inch gas pipes which are screwed into the hole tapped in the cast iron pipes. It will be noticed that the split tubes do not act primarily as the conductors of the main current, but mainly as a support for the conductors, and secondarily, by contact with these, as a means of connection to the houses, leaving the wires free to be removed or added to.

The seventh condition is to provide for getting round an obstacle. This is best done by having a hand hole at the ends of the cast-iron pipes on each side of the obstacle and joining these by lead-covered insulated cables of the full current-carrying capacity of the system. These cables can be bent round the obstacle, and are in no way a weak point of the system.

The method of laying the conductors in the ordinary routine is as follows. For a three-wire system for a maximum of 2,000 lamps of ½-ampère a three-inch gas pipe may be used. Each insulating disc has three one-inch holes in the positions of the angles of an equilateral triangle. In adding fresh lengths of conductor, three split tubes are first pinched at their ends and pushed into the ends of the three split tubes projecting from the last cast iron pipe laid. Two insulators are next run along the split tubes to a distance from either end of the tubes of one-fourth of their length. A fresh cast iron pipe is now run along over the split tubes and their insulators, the latter fitting loosely in the pipes. The joint of the pipes is made with packing in the ordinary way. A new length is added in the same way. Manholes must be placed at each corner of a street, and may be half a mile apart. The cast iron pipes fit into side holes in these boxes, and are fitted in with water-tight cement or packing. Wires are pulled through from manhole to manhole, and may be soldered together across the manhole. Finally, holes are drilled and tapped in the cast iron pipes beside those houses which require a supply of electricity. Two insulated wires, bared and flattened at their ends, are soldered to those split copper tubes which are of the right potentials. A 1 inch gas pipe is screwed into the hole tapped in the main pipe, and the insulated wire is thus led into the house.

AN ELECTRIC CURRENT METER.

By Prof. GEORGE FORBES, F.R.S.

(Section G.—Mechanical Science.—September 5th.)

AT the present moment the mind of electrical engineers is much directed to the successful means of distributing electricity to a large district from central stations by means of that class of induction apparatus which has received the several names of "secondary generator," "transformer," and "converter." This is the only thoroughly worked out system available to the engineer for an extensive supply of electricity. Currents of an alternating character (*i.e.*, alternately positive and negative in direction, the alternations being at the rate of some hundreds per second of time), and of high tension or pressure, are by this system carried from the engine house, by comparatively thin and cheap wire conductors, to the points of supply. The only difficulty which has been met is in the designing of a suitable meter. There is absolutely no meter available that pretends to be reliable. The very best indicates a totally different result when the same current is passed through it, if the number of alternations of the current (*i.e.*, the speed of the dynamo) be altered.

It was to overcome this source of trouble and to remove the last difficulty from an otherwise perfect system of electric distribution that the author undertook the labour of designing and perfecting the meter here described. Some idea of the work expended in bringing it to its present state of perfection will be gained when it is stated that the trial observations during the development of the instrument number nearly 10,000.

Seeing that the only electrical actions available were those of chemical action, electro-magnetic action, and heat, that the chemical method is incapable of being used with alternate currents, and that all electro-magnetic meters must vary in their indications with the rapidity of the alternations, the author was led to base his instrument on the heat developed by an electric current. Such an instrument must be equally applicable to continuous currents and to alternate currents, whatever their rate of alternations. Thus a meter is obtained which is practically perfect and more simple in construction than any of those designed for a more limited range of uses.

The instrument is extremely simple both in principle and in construction. It consists essentially of a flat spiral of iron wire with two terminals. Sometimes these two terminals are united to form one, the other being attached to the middle of the wire. Thus the instrument exhibited may be used as an accurate measure for currents from half an ampère or from 1 ampère upwards.

Above the conductor a set of vanes is pivoted. This consists of a circular disc of mica with a hole in the centre, in which is fixed a pinion with a concentric ruby cup. Round the circumference of the mica disc eight small cylinders of pith are fixed at equal distances, and eight vanes inclined at 45° to the mica discs are attached to the pith cylinders, these vanes being made of the thinnest mica. This set of vanes is supported with the ruby cup resting on a steel point fixed to the base of the instrument. The pinion engages with the first wheel of a train of clockwork actuating the indexes, which show upon two dials the number of revolutions made by the vanes.

The action of the instrument is very simple. The electric current passing through the iron conductor creates heat, which sets up a convection current in the air, and this causes the vanes to rotate about the vertical axis and drive the clockwork. The number of revolutions indicated on the dials is, through a considerable range of currents, an exact indication of the number of coulombs or ampère-hours which have passed through the conductor. The friction of the ruby cup on the pivot determines the smallest current which can be accurately measured, and the friction of the clockwork is imperceptible.

The following table shows the performance of one of these vanes. The conductor used had a resistance of 0·1 ohm; the first line shows the rate at which the current was flowing through the conductor; the second line gives the ratio of current to speed of rotation, a ratio which ought to be constant:—

Current in ampères .	·25	·35	·45	·6	·75	1	2	3	6	12
Ratio of current to speed . .	76	61·25	50·4	51	50·75	51	51	50·7	51	51·6

When using higher currents the ratio is equally constant.

AMERICAN NATIONAL ELECTRIC LIGHT ASSOCIATION.

ON STORAGE BATTERIES FOR ELECTRIC LOCOMOTION.

By A. RECKENZAUN.

The idea of employing secondary batteries for propelling vehicles is almost contemporaneous with the discovery of this method of storing energy. To M. Planté, more than to any other investigator, much of our knowledge in this branch of electrical science is due; he was the first to take advantage of the action of secondary currents in voltaic batteries. Planté is a scientist of the first grade, and he is a wonderfully exact experimenter. He examined the whole question of polarisation of electrodes, using all kinds of metals as electrodes and many different liquids as electrolytes, and during his endless researches he found that the greatest useful effect was produced when dilute sulphuric acid was electrolysed between electrodes of metallic lead.

A set of Planté original cells was exhibited for the first time, in March, 1860, before the Paris Academy of Sciences; scientists admired and praised it, but the general public knew nothing of this great discovery thus brought to notice. Indeed, at that period little commercial value could be attached to such apparatus, since the accumulator had to be charged by means of primary batteries, and it was then well known that electrical energy, when produced by chemical means in voltaic cells, was far too expensive for any purpose outside the physical laboratory or the telegraph office.

It was twenty years after this exhibition at the Academy of Sciences in Paris, that public attention was drawn to the importance of storage batteries, and that Mr. Faure conceived the idea of constructing plates consisting of lead and oxides of lead. At that time the advantages accruing through a system of electrical storage could be fully appreciated since electrical energy was being produced by mechanical means through the medium of dynamo electric machines.

It was the dynamo machine which created the demand for the storage battery, and the latter was introduced anew to the public at large and to the capitalist with great pomp and enthusiasm. One of Faure's accumulators was sent to Sir William Thomson, and this eminent scientist in the course of experiments ascertained that a single cell, weighing 165 lbs., can store two million foot-pounds of energy, or one horse-power for one hour, and that the loss of energy in charging did not exceed 15 per cent. These results appeared highly encouraging; there we had a method of storing that could give out the greater part of the energy put in. The immense development which the electric transmission of energy was even at that early day expected to undergo pointed to the fact that a convenient method of receiving large quantities of transmitted energy, and of holding it in readiness until wanted, must be of the highest importance. Numerous applications of the Faure battery were at once suggested, and the public jumped to the conclusion that a thing for which so many uses could be instantly found must necessarily be a profitable investment, and plenty of money was provided forthwith, not with the idea of commencing careful experiments, and developing the then crude invention, which would have been the correct thing, but for manufacturing tons of accumulators in their first and immature form.

I need not describe the disappointments which followed the first unfulfilled hopes, nor repeat the criticism that was heaped upon the heads of the early promoters. Those early hopes were untimely and unreasonable. A thousand difficulties had to be overcome—scientific difficulties and manufacturing difficulties. This invention, like most others, had to go through steady historical developments and evolution, and follow the recognised laws of nature which are against abnormal and instantaneous maturity. The period of maturity has also been retarded by injudicious treatment, but the ultimate success was inevitable. Great advances have been made within the last few years, and I propose now to offer a few facts and figures relating to the present state of the subject with reference to the application of storage batteries to locomotive purposes. It is not within the province of this paper to discuss all the different inventions of secondary batteries nor to offer any suggestions with regard to priority, therefore I will confine myself to general statements. I am aware of the good work that was done in the United States by Kirchoff 26 years ago, and of the more recent work of Mr. Brush, of Cleveland, Mr. Julien, and others, but I am more particularly acquainted with the recent achievements of the New York Accumulator Company who own the rights of the Electrical Power Storage Company, of London. I have used the batteries of the latter company for propelling electric boats and electric street cars. The first of the boats was the *Electricity*, which was launched in September, 1882, and which attained a speed of seven miles an hour for six consecutive hours. Since then a dozen electric boats of various sizes have been fitted up and worked successfully by means of storage batteries and motors of my design. The most important of these were the launch *Volta*, and another similar craft, which is used by the Italian Government for torpedo work in the harbour of Spezzia. In the measured mile trial trips the Italian launch gave an average speed of 8·43 miles an hour with and against the tide. The hull of this vessel was built by Messrs. Yarrow & Co., and the motors were manufactured by Messrs. Stephens, Smith & Co., of Millwall. The *Volta*, which was entirely fitted by the latter firm, is 37 feet long and 7 feet beam, she draws 2 feet 6 inches of water when carrying 40 persons, for whom there is ample sitting accommodation. There are 64 cells in this boat; these are placed as ballast under the floor, and actuate a pair of motors and a screw coupled direct to the armature shaft running at 700 revolutions a minute. We crossed the English Channel with this boat in September last year, leaving Dover at 2.40 in the morning, arrived at Calais at 2.30 p.m., stayed about an hour in the French harbour for luncheon and floated into Dover docks the same evening at 6 30 at full speed. The actual distance traversed without entirely discharging the cells was 54 miles; the current remained constant at 28 ampères until 5 p.m., and it only dropped to 25 ampères at the completion of the double voyage between England and France. Several electric launches are now being constructed in London, and one in New York by the Electric Accumulator Company.

M. Trouvé exhibited a small boat and a tricycle, both worked by Planté accumulators, at Paris in 1881.

The first locomotive actuated by storage batteries was used at a bleaching works in France in 1882. During the same year I designed an electric street car for the Storage Company, and this was tried on the lines of the West Metropolitan Tramways in March, 1883. It had accommodation for 46 passengers. This car had many defects, and I reconstructed it entirely, and ran it afterwards in its improved form on the South London Tramways, and also on a private track at Millwall, where it is now in good condition; I have a similar car in Berlin. M. Phillippart exhibited a car in Paris and M. Julien made successful experiments in Brussels, Antwerp, and Hamburg. Mr. Elieson is running storage battery locomotives in London. Mr. Julien has also been experimenting with a car in New York, and I believe one is in course of construction for a line in the city of Boston. Messrs. W. Wharton, jun. & Co. have a storage battery car running at Philadelphia on Spruce and Pine Streets, and this energetic firm is now fitting up another car with two trucks, each carrying an independent motor, similar to my European cars.

I have mentioned all these facts in order to show that there is a considerable amount of activity displayed in the matter of storage batteries for street cars, and that continued and substantial progress is being made in each successive case. The prejudices against the application of secondary batteries are being rapidly dispelled, and there are indications everywhere that this method of propulsion will soon take a recognised place among the great transit facilities in the United States. I feel convinced that this country will also in this respect be far ahead of Europe before another year has passed over our heads.

There are several popular, and I may say, serious objections to the employment of storage batteries for propelling street cars; these objections I will now enumerate and endeavour to show how far they are true, and in what measure they interfere with the economical side of the question.

First objection: The loss of energy, which amounts in practice to 20, and sometimes 30 per cent. Now, every method of storing or transmitting energy involves some waste, but in saying this we need not condemn the system, for after all the term efficiency is only a relative one. For instance, a 10 horse-power steam engine consumes three times as much fuel per horse-power hour as a 1,000 horse-power engine does, yet this small engine must be and is regarded as one of the most economical labour-saving appliances known to us. Considered as a heat engine the efficiency of the most economical steam motor is but 10 per cent.—90 per cent. of the available units of heat contained in coal being lost during its transformation into mechanical energy. Thus if we find that the storage battery does not return more than 70 per cent. of the work expended in charging it, we ought not condemn it on that account until we have ascertained whether this low efficiency renders the system unfit for any or all commercial purposes. It is needless to go into figures in order to show that, when compared with animal power, this objection drops into insignificance.

The second, a more formidable objection, relates to the weight of storage batteries—and this involves two disadvantages, viz., waste of power in propelling the accumulator along with the car, and increased pressure upon the street rails, which are only fitted to carry a maximum of five tons distributed over four points, so that each wheel of an ordinary car produces a pressure 1¼ tons upon a point of the rail immediately under it.

The last-mentioned objection is easily overcome by distributing the weight of the car with its electrical apparatus over eight wheels or two small trucks, whereby the pressure per unit of section on the rails is reduced to a minimum. With regard to the weight of the storage batteries, relatively to the amount of energy the same are capable of holding and transmitting, I beg to offer a few practical figures. Theoretically, the energy manifested in the separation of one pound of lead from its oxide, is equivalent to 360,000 foot-pounds, but these chemical equivalents, though interesting in themselves, give us no tangible idea of the actual capacity of a battery.

Repeated experiments have shown me that the capacity of a secondary battery cell varies with the rate at which it is charged and discharged. For instance, a cell such as we use on street cars gave a useful capacity of 137·3 ampère hours when discharged at the average rate of 45·76 ampéres, and this same cell yielded 156·38 ampère hours when worked at the rate of 22·34 ampères. At the commencement of the discharge the E.M.F. of the battery was 2·1 volts and this was allowed to drop to 1·87 volts when the experiment was concluded. The entire active material contained in the plates of one cell weighed 11·5 lbs., therefore the energy given off per pound of active substance at the above high rate of discharge was 62,225 foot pounds, and when discharging at the lower rate of 22·34 ampères the available useful energy was 72,313 foot pounds, or nearly 2·2 electrical horse-power per pound of active matter. But this active substance has to be supported, and the strength on weight of the support has to be made sufficiently great to give the plate a definite strength and durability. The support of the plates, inclusive of the terminals above referred to, weighs more than the active material, which consists of peroxide of lead and spongy lead, so that the plates of one cell weigh actually 26·5 lbs., add to this the weight of the receptacle and acid, and you get a total of about 41 lbs. per cell when in working order. Seventy of these cells will propel an ordinary street car for four hours and a half whilst consuming the stored energy at the rate of 30 amperes, or over 5·6 electrical horse-power. The whole set of 70 cells weighs 2,870 lbs., which is barely one-fifth of the entire weight of the car when it carries 40 adult passengers, therefore the energy wasted in propelling the accumulator along with a car does not amount to more than 20 per cent. of the total power, and this we can easily afford to lose so long as animal power is our only competition. From numerous and exhaustive tests with accumulator cars in this country and abroad I have come to the conclusion that the motive power for hauling a full-sized street car for 15 hours a day does not exceed $1.75, and this includes fuel, water, oil, attendance and repairs to engine, boiler, and dynamo. We have thus an immense margin left between the cost of electric traction and horse traction, and the last objection, that relating to the depreciation of the battery plates, can be most liberally met, and yet leave ample profits over the old method of propulsion by means of animals.

The advantages of storage battery street cars for city traffic are self-evident, so that I need not trouble you with further details in this respect, but I would beg those who take an interest in the progress of electric locomotive to give this subject all the consideration it deserves, and I would assure them that the system which I have advocated in this brief but very incomplete sketch is worthy of an extended trial, and ready for the purposes set forth. There is no reason why those connected with electric lighting interests in the various cities and towns should not give the matter their special attention, as they are the best informed on electrical engineering and already have a local control of the supply of current needed for charging.

(To be continued.)

THE CABLE RATE WAR.

NEW YORK, September 1st.—Manager Ward has just issued the following to the patrons of the Commercial Cable Company:—"On and after September 15th, 1887, our tariff will be 12 cents per word to Great Britain, Ireland and France, and 15 cents per word to Germany. We have, in justice to our patrons, decided upon this reduction in order to give them the benefit of the lowest rates during the time the tariff war may last." With reference to a statement that the company proposes to increase its capital stock from $4,000,000 to $6,000,000, the officials state that their repairing steamer, stations and equipment cost $9,000,000, for which $3,000,000 of bonds, $4,000,000 of stock were issued, and the balance has been kept as a floating debt. The company has now decided to issue the additional $2,000,000, which has been subscribed for by the proprietors themselves.

An item of gossip to-day was to the effect that the troubles of the California wheat clique will make Mr. Gould's negotiations with the Commercial Cable Company very much easier. A financial newspaper says:—"We understand that within 48 hours Mr. Mackay has offered all his interests to the Western Union Telegraph Company at a cash price. His anxiety may be inferred from that and from the other fact that he has threatened to serve notice to-day or to-morrow of a reduction of cable rates to 12½ cents. The latter outcome is the probable one, as the Western Union people are not inclined to be hurried on to advance cable rates unless they, and not Mr. Mackay, can name the rate.

As to the above, I am informed that no proposition has ever been made for the sale of the Commercial Cable Company to Mr. Mackay, as stated 10 days ago, neither has he received or made any proposition relative thereto.

The same paper states:—"The following is given as a theory concerning the reduction of tolls by the Commercial Cable Company: Mackay's counsel advised him that should the Commercial Cable Company raise its rates to the old rate, it would be liable for the payment of claims for the difference between the 25 cent rate for which it has been doing business, and the 12 cent rate of the old companies, and that, consequently, the only safe way to clear itself from liability was to first meet the 12 cent rate cut, and thus place all its patrons on the same footing, after which, upon nctice, rates may be again restored."

The officials of the company say this is absurd, as the Commercial Company have guaranteed their customers to refund, in case rates are raised above 40 cents.—*Financial News.*

NOTES.

Electric Lighting in St. James's.—In the report which the Vestry of St. James, Westminster, have just published, the subject of electric lighting is mentioned in the following terms:—"No progress has been made towards lighting this parish with electricity. Notice was received in the month of June of the intention of the West London Electric Lighting Company to apply for a further provisional order in the ensuing session, but this notice has not been followed up. The Board of Trade intimated their intention in the month of November to revoke the order granted to the West London Electric Company in 1884, in consequence of the undertakers having failed to show to the satisfaction of the Board of Trade, within the prescribed time, that they were in a position fully and efficiently to carry out the obligations imposed upon them. This order having been accordingly revoked, the Vestry are now free to entertain proposals for the lighting of the parish, or any portion thereof, by electricity."

Lighting Exhibition at St. Petersburgh.—The organisation committee of the exhibition of contrivances and materials used for lighting purposes, and also of everything connected with the naphtha industry, which takes place in the winter of the present year at St. Petersburgh, has intimated that applications from those who desire to participate in the exhibition will be received till the 27th of September, and the exhibits till the 27th October. In connection with this exhibition, the Russian Ministry of War offers a prize of 500 roubles "for a compact and practical battery for electric lighting with incandescent lamps."

The British Museum Lighting.—It was announced last week that the electric light would, from the 1st September, be put in operation for the season in the reading-room and galleries of the British Museum, and the hour of closing would be extended to 8 o'clock, except for the newspaper-room, which will continue to be closed at 6 p.m.

The Electric Light in Parliament.—The electric lighting plant of the House of Commons, says the *Financial News*, seems to be in a bad way. Mr. Plunket says nothing further can be done with it. Yet the First Commissioner of Works agrees that the substitution of electric lighting for gas throughout both Houses of Parliament is a thing greatly to be desired. But apparently the country cannot afford to throw an effective light upon parliamentary proceedings, or to save the stonework in the cloisters from the destructive effects which gas is exercising on it. There is, says Mr. Plunket, "that odious question of" expense to be considered. The First Commissioner has for some time been preparing estimates with the view of making the desired change, but, judging from the tone of his remarks, it will be some time yet before he ventures to submit them to the House. We say nothing of honourable members who breathe the air of Parliament. They may be able to stand the existing state of things better than the stonework, which is undeniably suffering detriment.

Swiss Telegraphs.—The number of telegrams passing over the Swiss lines in 1886 amounted to 3,077,862, or an increase of 167,732 over the traffic in 1885. At the end of 1886 there was a total length of 7,784 kilometres of line and 21,538 kilometres of conductors. The number of offices was 1,335, and the staff consisted of 1,751 employés, of whom 527 were females. There is an apparent diminution in the receipts for 1886 as compared with 1885, owing probably to the reduction of tariffs on international telegrams.

Electrified Rooms Company (Captain Arthur H. Byng's Patent).—We are requested by the directors of this company to explain that the liquidation and winding-up of the old company, notified in our columns, was simply a legal and necessary formality to enable them to reorganise the new company, which its extending operations required. It must be understood, however, that the paragraph in the ELECTRICAL REVIEW to which the directors of the above company refer in their letter to us was obtained from a document filed at Somerset House, with the other official records of the company, A notice of the registration of the new company formed to take over the business appeared in the REVIEW for May 6th.

Telephony in the Tees District.—Owing to the large increase in the traffic on its lines, the Northern District Telephone Company, Limited, has recently provided entirely new switching apparatus, and also made great alteration in the working of the exchange system in this district. At Stockton and Darlington the new arrangements have been in operation for some weeks, but the principal part of the work, namely, at Middlesbrough, was only completed within the last few days. The new work involved the alteration of about 160 wires, of which more than half had to be newly erected. In addition to this, all the switch-board arrangements had to be altered, and it is highly creditable to the engineer-in-charge (Mr. E. R. Widdicombe) and his staff that the whole of the work was carried out without a single hitch. The trunk system of the company has also recently been completed, and communication can now be had from Middlesbrough, South Stockton, East and West Hartlepool, Sunderland, Newcastle, North and South Shields, Tyne Dock, Blyth, Durham, Bishop Auckland, and Darlington. There are also now two distinct routes from Newcastle to Middlesbrough, viz., *viâ* Durham, Bishop Auckland, and Darlington, and *viâ* Sunderland and Hartlepool, so that it is almost impossible for communication to be entirely interrupted. The exchange at Middlesbrough is now open day and night, Sundays included. This will be found of special use in case of fire and other emergencies, as the exchange is in direct communication with the fire and police stations. The company have connected the Cottage Hospital free of rental, and they expect by keeping the exchange open day and night that a considerable number of private residences and shops will be induced to join the system. The various departments—editing, printing, and commercial—of the head offices of the *Northern Echo* are connected by telephone, and the branch offices at Middlesbrough and Stockton are by the same medium brought within speaking range of the head office.

Continental Central Stations.—The Vienna correspondent of *Industries* states that although the contract for the erection of a central station in Neubad has been concluded between the town authorities and Messrs. Siemens and Halske, the actual work on the site of the proposed station, has not yet begun. Before the station can be erected some old buildings will have to be demolished. Meanwhile the firm are busy with the wiring and fitting up of some restaurants and cafés in the district, which will ultimately be supplied from that station. A small central station has been started in Baden, near Vienna, the generating plant having been put up in a disused mill. The total number of gas jets in use in Baden is about 6,000; the cost of gas lighting being about ·58d. per burner per hour to the commune, and ·7d. per burner per hour to private persons. Considering these heavy charges, it will evidently be easy to supply the electric light at a cheaper rate, and the inhabitants of Baden are as a general rule favourably disposed towards the electric light. An extension of the installation so as to include public supply will therefore shortly take place.

A Huge Telephone Scheme.—We see that a scheme has been formulated in the Midlands for the establishment of a centre of the National Telephone Company in Warwickshire, in connection with the existing wires of the company in Lancashire and Yorkshire. The company at present has a system of trunk lines in Lancashire and Cheshire, which are connected with those of Yorkshire, forming a system of telephonic communication between Liverpool on the west and Leeds on the east almost as perfect as that of the telegraph. The following among other towns are included in this system, from any one of which telephonic communication can be had with any of the others :—Liverpool, Birkenhead, Warrington, Runcorn, St. Helen's, Wigan, Southport, Bolton, Manchester, Preston, Blackpool, Fleetwood, Blackburn, Accrington, Burnley, Darwen, Bury, Rochdale, Todmorden, Sowerby Bridge, Halifax, Bradford, Huddersfield, Dewsbury, Wakefield, Leeds, and Sheffield. The "National" has just projected a scheme which will, when carried out, connect all the chief towns in the Midlands with this gigantic system throughout Yorkshire and Lancashire. Already the construction of the lines has been commenced, and when the whole of them are completed a number of other trunk connections are contemplated within the area so as to make it complete. The proposed lines go as far north as York and Lancaster, and a contemplated line will go on to Scarborough.

New Combinations for Voltaic Cells.—A novel series of voltaic combinations, in which solutions of alterable compounds are substituted for the attackable metals, has lately been investigated by Dr. Alder Wright and Mr. C. Thompson ("Journ. Chem. Soc.," August, 1887). The chief feature of the new cells consists in the replacement of the zinc or its equivalent by a plate of carbon, platinum, or other conducting but unchangeable substance, immersed in a solution of some easily oxidised or chlorinated compound, and opposed to a similar plate in contact with the solution of a substance capable of being readily deoxidised or dechlorinated. The plate in contact with the oxidisable fluid acquires the lower potential or becomes the negative pole, while the other plate takes the higher potential and forms the positive pole with regard to the outer circuit. An almost endless variety of new combinations may thus be employed, some of which may be expected to develop considerable energy. A convenient cell, of electromotive force 1·5 volt, consists of a U-tube, into one limb of which is poured a solution of sodium sulphite, while a solution of "chromic liquor," that is, a mixture of sulphuric acid and potassium bichromate solution, is run into the other, a little moderately concentrated sulphuric acid being previously placed in the bend to prevent too rapid diffusion of the two. On placing the two platinum plates in their respective solutions and completing the external circuit by a wire, a constant current is maintained, owing to oxidation of the sulphite to sulphate, and reduction of the chromic acid to chromium sulphate. In all the cases examined the currents were remarkably steady, and capable of performing measurable amounts of electrolytical work.

Telephonic Communication Between Marine Forts.—In connection with an elaborate scheme which is now under consideration for the strengthening of the forts which command the entrance to Spithead, it is proposed to lay a submarine telephonic cable connecting the various forts with each other and with the mainland. At present no proper method of communication exists, and it is felt that in case of actual hostilities, when these forts might perhaps play a very prominent part in repelling an attack on the dockyard and naval arsenal of Portsmouth, the lack of some ready means of transmitting messages would have a most serious effect. Submarine electro-contact mines will also be laid in the channels approaching the roadstead.

The Western Electrical Works, Bristol.—One of the most complete establishments in the kingdom for the manufacture of every description of electrical apparatus is that carried on at Bristol by Messrs. King, Mendham and Co., and their catalogue of which a new edition is just issued, is one of the most comprehensive of the kind, consisting of 140 closely printed pages with cuts on almost every page. An increasing business and the introduction of improved machinery and methods of production, have enabled the firm to make considerable reductions in prices, and builders and bell fitters will find on a perusal of the price list that their requirements have had special attention. Ironmongers and others desirous to keep pace with the times and to be able to undertake any kind of electric bell fitting, can be supplied with sets of apparatus for exhibition in windows and show rooms, and with model doors or windows fitted with burglar alarms. These and the ordinary technical terms and standards are illustrated and explained in the catalogue and directions given for different operations. The Wimshurst influence machine has been made by Messrs. King, Mendham & Co., from the time when it was first introduced by Mr. Wimshurst, and they are able to supply not only complete apparatus of any size, but also any special parts. They continue to make the machines with glass plates, their experience having taught them that for many reasons glass is superior to any other material for this purpose. Some new forms of the machine are shown in the price list, which includes also other novelties in the way of automatic gas lighting apparatus, alarm, and signal clocks and many other things.

A New Scientific Authority. — The *Investors' Guardian*, of July 9th, devotes an article to the humid voltaic combination which concludes thus :—"We have made a thorough and most searching investigation of the water primary battery, and the more we ponder over our notes and weigh all the probabilities, the more convinced are we that the public have at last secured the light of the future." The readers of the *Investors' Guardian* have evidently reason to congratulate themselves that there exists on the staff of that journal one who can see so far into the future, and who has such a store of knowledge connected with the electrical doings of the past.

The Electric Light at the Portsmouth Theatre.—The Theatre Royal at Portsmouth is generally considered to be one of the safest buildings of the kind in the United Kingdom, but as a further precautionary measure Mr. J. W. Boughton, the lessee, contemplates adopting the electric light instead of gas. On the occasion of the Jubilee celebrations, the exterior of the theatre was beautifully lighted by means of three large arc lamps, and Mr. Boughton is fully satisfied as to the advantages of an electrical system of illumination.

Which is Which ?—Mr. Fredk. J. Varley, one of the eminent experts who has reported upon the D'Humy battery, thus describes it :—The negative element is carbon immersed in nitric acid, and the positive, iron immersed in water, the latter becoming acidulated by the percolation of the nitric acid through the porous diaphragms, separating the stronger from the weaker solutions. After having read, marked, learned, and inwardly digested this, who will be bold enough to say wherein it differs from that of M. Maiche ?

The "Manchester" Dynamo.—In examining this machine at the Manchester Exhibition the other evening, we observed a peculiarity which formerly escaped our notice. Whilst the clearance between the armature wires and the polar surface is about $\frac{1}{8}$th of an inch at the centre of the poles, from there it gradually increases until at the tips it is half-an-inch. The object is doubtless to prevent leakage across the poles and to obtain a uniform field. But it is interesting to see a device employed some years ago revived, and with the same object in modern dynamos.

Volk's Electric Railway.—At the Brighton Town Council last week, Councillor Challis made a proposition to the effect that owing to the delay of the Works Committee in bringing up their report in reference to the above, the instruction to them of March 3rd last should be rescinded, and a special committee appointed to deal with the matter. The delay which had ensued (he said) gave people the opportunity of suggesting that the committee had some interest in the continuance of the railway. After a short discussion an amendment was carried instructing the committee to bring up their report within a month. The gale of September 2nd did not occasion any extensive damage at Brighton, although the sea carried away large quantities of the beach. At the east end the electric railway was flooded, but was not otherwise damaged.

The Swinton Telephone.—The Postmaster-General has granted the Equitable Telephone Association, Limited, a license to establish telephonic exchanges in the United Kingdom. Our readers are aware that the apparatus controlled by the association is that patented by Mr. A. A. Campbell Swinton.

The Spiel Petroleum Engine.—The shareholders in Spiel's Patent Petroleum Engine Company, Limited, do not appear likely to reap any benefit yet awhile. Litigation seems to be at the bottom of it all, and, in the meantime, the introduction of a really valuable invention is seriously hindered. If patentees, manufacturers, and the company's directors can only manage to work amicably together we believe, with the chairman, that the success of the company is only a matter of time.

Bradford Post Office.—The new post office at Bradford was opened for postal business on the 1st. inst., but the telegraph department still remains at its old quarters in Tyrrel Street. It is stated that owing to the new building not being in a central position for business men—a correspondent in a local paper referring to it as the new post office in the suburbs—the existing head telegraph office will have to be kept open, and a pneumatic pipe connection made between it and the new premises, a distance of about a quarter of a mile. The telegraphs will be transferred to the new instrument-room after the pipe has been laid.

Practical Electrical Measurement.—Mr. Swinburne's paper came to hand this week too late for publication in our present issue.

An Extraordinary Meter.—We have had sent to us a reprint of an article which appeared in *Iron* of August 26th, descriptive of the water primary battery. This is only surpassed by that which appeared in the *Morning Post*, and to which we referred last week. But the only portion of this elegant contribution to electrical literature to which we will draw attention is that relating to D'Humy's meter. This, we read, "controls the *light consumed per minute*, a most ingenious arrangement, by which house-to-house lighting becomes perfectly practicable." Householders, rejoice !

Incandescent Lamp Patents.—We have received a letter from Mr. Hamilton in reply to that of Mr. Sinclair, but too late for publication this week.

Atlantic Cable Rates.—A circular from the Bureau International at Berne dated August 31st, informs us that the Commercial Company will reduce to 6d. per word the rate between the United States and France, England, and Germany, the new rate to take effect from the 15th inst.

Voltaic Combinations.—It oftentimes happens that would-be inventors re-discover ideas which have long ago been abandoned, and this just now is specially the case with voltaic batteries. To save much loss of time and mis-directed ingenuity, we would recommend these gentlemen to peruse A. Niaudet's elementary treatise on voltaic batteries.

Electric Fairy Fountains.—The lighting committee of the Glasgow International Exhibition Executive has reported that arrangements have been made with Messrs. Galloway & Sons, of Manchester, for the erection of a fairy fountain, the base of which is to be 190 feet in diameter and containing 100 jets. The electric light will be manipulated from a distance of 200 feet, and 150 horse-power will be necessary to give the required amount of light.

Sale of Electrical Plant.—On Tuesday next, the 13th, an important sale will be conducted by Messrs. Wheatley Kirk, Price, and Goulty, of the electro-depositing plant and machine tools at the works of the Electro-Metallurgical Company, particulars of which are given in an advertisement. Catalogues may now be had from the auctioneers. There are to be sold about 23 Elmore and other dynamos, a magneto-electric machine, made by Woolrich in 1842, being described as a curiosity, from the fact that it was one of the first ever constructed. This machine was exhibited, on account of its historical interest, at the Crystal Palace Electric Exhibition, 1881.

Primary Batteries.—A French exchange says:—"A great deal has been said in certain English journals with reference to a nitric acid primary battery whose elements are iron and carbon. This is not the first time that batteries, of which iron is one of the electrodes, has been suggested, but we cannot see in what way the employment of costly nitric acid can offer any advantage. It appears that there are still some people who are not yet convinced of the uselessness of researches of this kind, and England is at this moment the 'happy hunting ground' of inventors who cannot place their patents in Paris."

Maiche's Battery.—In the battery devised by M. Maiche in 1864, there is a cylinder of soft sheet iron immersed in water feebly acidulated with nitric acid, which plays the part of the positive electrode. The porous pot is very high and closed by a cover through which the carbon passes freely. It contains nitric acid which by percolation through keeps up the acidity of the external liquid. The above may be found on pp. 216 and 217 of *Traité Elementaire de la pile Electrique*, par A. Niaudet, 1885. The explanation of its action which M. Monnier is now so intently studying is also given. Does it not appear from this that the last five years of Mons. D'Humy's existence might have been better spent than in reinventing a battery which, figuratively speaking, is as old as the hills. Mr. Gooch perhaps may also derive a lesson from this.

Personal.—Messrs. Muir, Mavor, and Coulson, of Glasgow, announce that they have assumed as partner Mr. J. D. F. Andrews, lately of the Woodside Electrical Works.

Erratum.—Page 209.

For

$$-\mathrm{R}\,t = \frac{1}{1+\sigma C_1}\log(1+\sigma C) - \frac{\sigma C_1}{1+\sigma C_1}\log\frac{C_1-C}{C_1} - \frac{L_0+\sigma C_1}{(1+\sigma C_1)^2}\log(1+\sigma C) - \frac{\sigma(L_0-1)C}{(1+\sigma C_1)^2} + \frac{L_0+\sigma C_1}{(1+\sigma C_1)^2}\log\frac{C_1-C}{C_1}$$

read

$$-\mathrm{R}\,t = \frac{1}{1+\sigma C_1}\log(1+\sigma C) - \frac{\sigma C_1}{1+\sigma C_1}\log\frac{C_1-C}{C} - \frac{L_0+\sigma C_1}{(1+\sigma C_1)^2}\log(1+\sigma C) - \frac{\sigma(L_0-1)C}{(1+\sigma C_1)(1+\sigma C)} + \frac{L_0+\sigma C_1}{(1+\sigma C_1)^2}\log\frac{C_1-C}{C_1}$$

NEW COMPANY REGISTERED.

Cowles Syndicate Company, Limited. — Capital £150,000 in £10 shares. Objects:—To carry on business as smelters and reducers of metals by electricity, or otherwise; also to manufacture aluminium and its alloys and to treat and convert into metal by electrolysis or other means, ores, minerals, oxides, or solutions of any kind. For such purposes the company will enter into an agreement with the Cowles Electric Smelting and Aluminium Company, of Cleveland, Ohio, U.S.A., for the purchase of certain patent rights. Signatories (with one share each): *S. French, 2, Addison Road; *H. C. S. Dyer, Newcastle-on-Tyne; *R. Thornwill, Burton-on-Trent; *B. Plumb, 36, Lombard Street; S. G. Browne, 77, Edlesham Road, Balham; W. Roby, 10, Dartmouth Park Road, Highgate; G. Allen, C.E., 10, Austin Friars. Directors' qualification, £200 of share capital. The signatories denoted by an asterisk and Mr. A. S. Bolton, of Cheadle; Edwin Cowles, of Cleveland, Ohio, U.S.A., and Robert Heath, of Congleton, are the first directors. The remuneration of the board is to be £400 per annum and 5 per cent. per annum of the profits available for dividend. Registered 31st ult. by Ashurst, Morris and Crisp, 6, Old Jewry.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Carlyle-Elmore, Limited.—An extraordinary general meeting of this company was held at the offices of Mr. Arthur Hy. Foster, of 13, Bennett's Hill, Birmingham, on July 18th, when it was resolved—"That it having been proved to the satisfaction of this meeting that the company cannot by reason of its liabilities, continue its business, and that it is advisable to wind up the same, it is hereby resolved that the company be wound up voluntarily, and that Frank Impey, of 41, Temple Street, Birmingham, the secretary of the company, be and is hereby appointed liquidator, for the purpose of such winding up, at a remuneration of 5 per cent. upon the gross value of the assets realised." This resolution was duly registered on July 20th.

Winfield's, Limited.—The statutory return of this company made up to June 7th was filed on June 13th. The nominal capital is £160,000 divided into 24,000 preference and 8,000 ordinary shares of £5 each. The shares taken up are 15,955 preference and 8,000 ordinary upon which the full amount has been called up. The calls paid is £66,560 and unpaid £215. The sum of £53,000 is considered as paid upon 2,600 preference and 8,000 ordinary shares. Registered office, 47, Holborn Viaduct.

Rose Primary Battery, Limited.—The statutory return of this company made up to July 2nd was filed on July 7th. The nominal capital is £50,000 in £1 shares, but the only shares recorded as taken up are the seven subscribed for by the signatories to the memorandum and articles of association.

Edison and Swan United Electric Light Company, Limited.—The annual return of this company made up to the 23rd ult. was filed on the 31st ult. The nominal capital is £1,000,000 in £5 shares. The shares taken up are as follows:—17,139 fully paid, 23,564 fully paid B shares, and 89,261 ordinary shares with £3 per share paid up.

West African Telegraph Company, Limited.—The annual return of this company made up to the 3rd ult. was filed on the 1st inst. The nominal capital is £400,000 in £10 shares, 23,109 shares have been taken up and the full amount has been called and paid up thereon.

London Electric Supply Corporation, Limited.—The registered office of this company is situate at 79, Grosvenor Street, W.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of August was 2,983, estimated to produce £2,230, against 2,848 messages, producing £2,163 in the corresponding month of last year. The receipts for the month of May, estimated at £3,050, realised £3,061.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 31st August are £2,010, as compared with £2,003 in the corresponding period of 1886. The May receipts, estimated at £5,651, realised £5,737.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending September 2nd were £2,820 after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Great Northern Telegraph Company, Limited. The receipts for August, 1887, £23,000; from January 1st to August 31st, 1887, £174,120; corresponding months, 1886, £169,000; and of 1885, £192,040.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of August were £1,614, against £1,379 in the corresponding period of last year.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending 31st August are £4,525.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

8137. "An improved method for the construction of incandescent electric lamps." A. SWAN. Dated June 19. 8d. Claims:—1. The manufacture or construction of incandescent electric lamps, wherein the cap or part containing the contact pieces, and by which the lamp is secured to, and contact is made with the support, is made an integral part of or with the lamp proper, bulb, or vacuum chamber, substantially as described. 2. The manufacture of incandescent electric lamps of a part of glass and a part of "vitrite," or the like, sealed together, the last-named part having large contacts sealed therein, to the inner sides of which the supports of the incandescing medium are affixed, substantially as described.

9310. "A new or improved machine or apparatus for giving or producing electric shocks." N. W. RUSS. Dated July 17. 1s. 3d. The object of this invention is to enable persons in public and other places, such for example as railway stations, exhibitions, and other public places, or even in private houses or other places to obtain an electric shock, or a current of electricity without the aid of an attendant, but not until a coin of a certain size, such as a penny, has been inserted in a receptacle provided for same. The claims are 9 in number.

9694. "New or improved manufacture of the incandescing portion or luminant of incandescence electric lamps." T. MACE. (Communicated from abroad by the Vitrite and Luminoid Company, of New York.) Dated July 27. 6d. Claims:—1. A material for use in the manufacture of the incandescing portion or luminant of electric lamps consisting of or containing a combination of organic or carbonisable substance with alumina, substantially as described. 2. The manufacture and use of a material for the incandescent or luminant of electric lamps consisting of alumina together with an organic or carbonisable body, the mixture being heated in absence of oxygen and other injurious gases, with or without further heating, with an organic compound of aluminium, substantially as set forth. 3. The manufacture and use of a material for the incandescent or luminant of electric lamps, consisting in saturating an organic or carbonisable material or body with a salt or compound of aluminium decomposing the said salt or compound so as to obtain alumina, then washing and afterwards heating out of contact with free oxygen and other injurious gases, with or without further heating with an organic compound of aluminium, substantially as set forth. 4. The manufacture and use of a material for the incandescing portion or luminant of electric lamps by saturating or impregnating an organic or carbonisable material with oxide of aluminium or a salt from which the oxide is subsequently produced, substantially as described, then enveloping the same in a paste of the same oxide shaping and finishing the same and heating with the exclusion of oxygen and other injurious gases, with or without further heating, with an organic compound of aluminium, substantially as described.

9846. "Improvements in transmitting instruments for submarine and other long-distance telegraph lines." A. M. CLARK. (Communicated from abroad by L. Maiche, of Paris.) Dated July 30. 8d. Consists in a new system of automatic distributor of the currents necessary for transmission, which permits of retaining the ordinary mode of sending and receiving with undiminished rapidity, whilst affording facility for interruption and repetition as may be required. The instrument consists of: (1.) An ordinary double key worked by hand, and having no other function than to determine, by means of a local battery, the release of the distributing apparatus. (2.) A current distributing apparatus, consisting, on the one hand, of a clock-train, actuated either by a spring barrel, or other power, whereby a regular rotary motion is obtained for actuating the distributor proper. The distributor consists of a train of clockwork having continuous motion, the last shaft of the train being governed by a fly, and rotating at a given speed, and carrying eccentric or cam-like contact discs which are driven from the shaft by friction gear. The contacts are normally held at rest by detents, but when one of them is released by the action of a local current established by means of an ordinary key used as a manipulator, one of the contacts is allowed to make a single revolution, after which it is again arrested. During the revolution it touches successively two contact springs whereby, first, a working current is sent through the line, and afterwards a current for neutralising the residual charge. The position of the contact springs is capable of being so regulated as to give to the charge and discharge durations proportional to the capacity of the couple and adjustable according to its daily condition. Claim:—The described system of transmitting instrument whereby currents of alternately opposite polarity are automatically distributed to telegraphic lines, the instrument consisting essentially in a combination with a motor mechanism having a uniform motion, of a combination of contacts actuated by friction gear and controlled by the armatures of electro-magnets, energised by the action of a local current, substantially as specified.

9959. "Improvements in electrical firing keys or contact makers." C. A. MCEVOY. Dated August 3. 8d. Claim:—The construction of electrical firing keys or contact makers in the form of a pistol and with the front end made to turn downwards when the trigger has been pulled and the contact made, substantially as described.

CORRESPONDENCE.

Reckenzaun's Secondary Battery.

In briefly referring to your recent article headed "Reckenzaun's Secondary Battery," I trust that it will be understood that I have no desire to question the useful and practical work which we all readily recognise as having been done by Mr. Reckenzaun in connection with electrcal traction (the facilities for carrying out which work, he will, however, I am sure be the first to admit, were afforded him by the Electrical Power Storage Company at very considerable cost to themselves) but in connection with the form of battery plate described as having been patented by him, I feel called upon in the interests of the E. P. S. Company to quote a claim in my specification, No. 2,818, 1882, for—"Forming plates or retainers for secondary batteries with *interstices*, perforations, or *spaces*, which *key, lock, or firmly retain* in position the material with which the plates are packed"—which taken in conjunction with the descriptive matter, illustrations, and claims of Mr. T. W. Swan's patent, No. 2,272, 1881, and my earlier patents, Nos. 3,926 and 3,987, of 1881, in which elongated and tubular interstices are shown (the property of the Electrical Power Storage Company) must be considered *as governing any form of interstical plate holding packed material.*

Some of the advantages categorised as specifically inherent to the particular form of plate described in your article, as also the remarks made as to the cost of its manufacture relatively with the E. P. S. plate may be more or less open questions, but upon the point of the so-called "buckling" which it might be inferred by some of your readers is a necessary evil with all forms of plate hitherto made, I am anxious that it should be understood that no buckling or distortion will or even can take place with the grid or any analogous form of plate if the well-known principles of manufacture are attended to in the first instance, and if the most simple rules of treatment in working are subsequently followed; whereas on the other hand every form of secondary battery plate is liable to injury in the absence of these conditions which are obviously essential to the successful manufacture and working of electrical apparatus of any class.

John S. Sellon.

September 7th, 1887.

Under the above heading in your last edition various points of interest are raised in connection with the construction and working of secondary cells.

It appears to me that with regard to one of these points, viz., buckling, some misapprehension seems to exist, and I would wish, from personal experience, to take exception to the statement made by your correspondent that "it is well known the paste in the grid expands during conversion into peroxide. This expan-

sion takes place in each square, and consequently all over the plate; but, unfortunately, as the natural result of varying mechanical resistance offered by the support, not evenly. Thus the paste in the centre of a square plate will have a considerable resistance to overcome by virtue of all the surrounding substance, whereas those parts nearer the edges encounter less opposition and expand more freely, hence a plate *must become distorted*, a state generally termed buckling. Two neighbouring plates, if they do not buckle in the same direction, will thus come into actual contact, and in the endeavour to prevent this the manfacturers place India-rubber plugs into the plates at short distances apart, so as to render the free unsupported surfaces as small as possible. These precautions, however, do not remove the tendency to unequal expansion; they merely offer a rude remedy which cannot remove the cause. Moreover, it occurs very frequently that the lead frames burst after prolonged use, this being another result of unequal expansion."

It must be admitted that plates have in many cases been found to show the symptoms described, the cause of which is attributed by the writer of your article to the process of formation and to the shape of the plate, it being suggested that because a plate has square holes it must buckle, whereas one with slots will not do so on account of expansion being only in the direction of length. This, I would say, is not necessarily so.

With regard to expansion affecting the plates during their formation, when we consider the composition of the plate there cannot be much expansion, for we have in the peroxide plate when first prepared $Pb_3\ O_4$, with, say, about a quarter of Pb SO_3, if we take Pb as 100, $Pb_3\ O_4$ as 148, Pb SO_3 297, Pb O_2 being 160, there seems to be but small margin for variation of bulk.

If the formation is properly performed the conversion of the material is singularly regular. It commences at the support or frame and gradually penetrates through the mass of paste, each hour of charge adding to the conductivity of the plate. On completion of the process of formation plates are as perfect in form as when pasted.

The employment of India-rubber plugs is not for the purpose of preventing buckling, as plates of the type mentioned work quite as well with sticks or rings; the plugs are simply a convenient method of keeping the plates equidistant.

With regard to the statement that the paste detaches itself from the conical supports and drops out in halves, this, though sometimes brought about by bad treatment, is, I believe, at the present time of rare occurence.

K.

September 5th, 1887.

The Causes of Unsteadiness in Arc Lamps.

Mr. J. Swinburne terminates his brief note on arc lamps by a somewhat strangely worded and misleading remark. The assertion that a good arc lamp should burn cheap carbons without flickering and that any lamp will burn well with expensive carbons is, if taken literally, a theory of the most startling description and about as terrible as would be the pretension that a good gas burner ought to give a satisfactory light when supplied with non-purified gas. It would be interesting to know what possible construction of an arc lamp could eliminate the effect of the impurities contained in the carbons upon the fixity of the light. I am aware that some such advantage has been claimed for a lamp invented by Mr. Edison, as also for "la Lampe Soleil," but those suggestions having proved practically failures, it is useless to discuss them here; it is probable, moreover, that Mr. Swinburne refers to veritable arc lamps, leaving semi-incandescent and all other unpractical systems out of the question.

I have yet to learn that good carbons can make a radically bad regulator work well. Of course, all lamps give a better light with good carbons than with bad, but the carbons can never change the nature of the lamp, nor *vice versâ*. The most homogeneous carbons, such as those of Siemens, for example, burnt in a lamp based upon a faulty principle, ill designed and ill adjusted, such as the Brush, for example, or any other of the innumerable clutch systems, will never give as steady a light as when they are held in a regular working lamp susceptible of careful adjustment, such as those of Siemens, of Cance, or of Berjot.

I may here remark that facility of adjustment should be regarded as one of the chief points to be considered in designing an arc lamp, being second only in importance to the slowness and regularity of the feeding movement. The suppression of the regulating screws in some types of lamp cannot therefore be regarded as an advantageous proceeding. It should not be forgotten that for a given current and diameter of carbon there is an arc length varying within very narrow limits which produces the best effect; should the arc lengthen, its illuminating power decreases considerably, should, on the other hand, the distance between the points diminish, a hissing arc will be produced, "*Incivit in Scyllam, cupiens vitare Charybdin.*" A careful adjustment and a regularly working lamp are requisite to maintain the happy medium. Moreover, a point of unstable equilibrium exists between the length at which the arc becomes silent and that at which it commences to hiss. Sometimes a badly regulated lamp maintains the carbons fast at this "critical" distance, the period of hissing and of silence succeed each other rapidly, and the result is a most abominable flickering and spluttering. More often, and especially in the ring clutch type of lamp, one sees the arc pass through all the stages in rotation; hissing, unstable equilibrium and spluttering, finally passing into a silence which lasts until the clutch lets go the carrier, whereupon the cycle recommences.

Partisans of the short hissing arc are not wanting, especially among American electricians, by whom the short arc has been adopted as a means of avoiding the effects of the unstable conditions above mentioned; the idea being that when working with a short arc the sudden fall of the upper carbon would have less effect upon the steadiness of the light. This is found to be actually more or less the case in practice, since an irregularly working lamp will give a better light when adjusted for a short arc, than when one attempts to adjust the arc to its proper length. Nevertheless, the short arc is a Yankee absurdity, for the reason that the close proximity of the points causes the negative carbon to screen the incandescent crater of the positive; moreover, it must, I think, be admitted that the hissing sound produced, the rapid flicker of the light and its disagreeable colour are serious additional disadvantages. Although in reality by no means economical, the Americans have the "notion" that the short arc is the most efficient. This fallacious idea results from the greater *horizontal* photometric effects as was pointed out in these columns by Prof. Elihu Thomson. The idea of the economy of the short arc has thus an origin analogous to that of the belief prevalent in "the States," that the luminous effect of an undulatory current such as generated by the Brush, Thomson-Houston, and Edward's dynamos is greater than that of the almost continuous current of machines constructed on the Paccinotti, Gramme, or Siemens-Alteneck systems.

Yet another argument in favour of lamps constructed with a view to the easy adjustment of the arc length, lies in the fact that what may be termed the "critical" distance between the points varies according to the make of the carbons. Thus a good lamp adjusted to give a satisfactory arc with a certain make of carbon, might produce a spluttering or a flaming arc with carbons of another variety, and in either case the remedy would consist simply in readjusting the lamp so as to work with a longer arc in the first case, and with a shorter in the second. Evidently one should not reject as bad a sample of carbon because it refuses to burn well in a lamp adjusted to burn electrodes of another manufacture.

Returning to the subject of electric light carbons and to the consideration of the views of Mr. Swinburne, I

would ask that gentleman whether he classifies cored or "wick" carbons amongst those of an expensive character? If so, it would be curious to know by means of what system of lamp a perfect fixity of the arc could be obtained, ordinary solid rods being employed? It is well-known that one of the great causes of flickering in arc lamps is the shifting of the arc upon the points. This shifting movement occurs in an exaggerated form with the candles of Jamin, Wild, and others, to a less extent in that of Jablochkoff, and rises to gigantic proportions in the obsolete carbon plate lamps of Andrews and of Wallace. It is least noticeable in the usual systems with the carbons in the same vertical line, but is nevertheless a source of much unsteadiness, the sole remedy being the employment of a cored positive carbon, since the soft core burning more rapidly than the surrounding mass, produces a well-defined crater, which remaining always in the middle of the rod, maintains the arc in a central position. Of course the core does not do away with the unsteadiness caused by impurities in the carbons, nor can it be obviated by any perfection of the lamp mechanism, Mr. Swinburne to the contrary notwithstanding.

Many carbons give off fits of gas, veritable "blowers," which cause a most disagreeable flickering. Copper-sheathed carbons give an unsteady light, while the half-fused copper around the points casts unsightly shadows, their alleged advantages are moreover illusory. The selection of a make of carbons is a more important matter than the majority of electrical engineers seem to think, nor must it be fancied that good carbons must necessarily be dearer than bad. To enumerate here the advantages and the reverse of the various makes of carbon in the market would be inadmissible, but I may say that my experience of those of American manufacture has not been such as to encourage me to recommend them. At least a great many of the American varieties of carbon are simply rubbish, which no earthly power could coax or force to burn well.

In order to produce a perfectly steady light by the arc system, lamps very different from those generally seen in England or the United States should be employed. In most lamps the acceleration of the velocity of descent of the upper carbon holder and the inertia of the moving parts militate against the satisfactory working of the apparatus by allowing the carbons to come too close together. This defect is conspicuous in all clutch lamps, and exists even in those provided with a train of wheelwork. It was to do away with this disadvantage that Gramme invented his well-known lamp, in which the current in the shunt magnet is interrupted whenever the armature is attracted. The same object has been more perfectly attained in the lamp devised by M. Abdank-Abakanowicz.

Doubtless the ideally perfect arc lamp should be independent of gravity and provided with two movements, so as to either increase or diminish the distance between the points, as in the Foucault-Dubosq regulator, or in the lamp patented by Messrs. Gatehouse and Kempe, but this latter refinement is hardly necessary in practical lighting.

Most devoutly is it to be wished that ere long the Darwin-discovered process of natural selection will have effaced from the surface of this mundane sphere the abominations in shape of arc lamps so numerous and so conspicuous by their nerve-racking and eye-torturing attributes. Let ring clutches, short arcs, solid carbons, copper-coated ditto, ill-adjusted lamps, and those incapable of adjustment, pass from off the earthly stage into a night so profound that their *ignis fatuus*-like glory will be unable to penetrate its shades, for when all these horrors have sunk into the gloomy abyss of the electrical Nirvana, or in plain terms are relegated to the chapter on obsolete devices in the text books of the future, a new and brighter era, a veritable epoch of sweetness and light will have dawned throughout the world for electrical illumination.

The advent of this delightful period is a question of time. Time alone can free the world of these things.

Tout lasse, tout casse, tout passe. May thus the users of certain horrible systems that shall be nameless have soon enough of them; may the internal economy of these "highly reliable" lamps get deranged, and may they finally be thrown upon the scrap-heap! Such should be the fervent desire of all right-thinking "electric light-men" (as the Yankee language has it) who give a thought to the fate of posterity, since ere this devoutly to be wished for consummation it is probable that most of us, beings of a day, sparkling ephemera, will have been ferried across the darkly-flowing river, or be wandering on the shadowy shore of the classical Αχέρων!

F. de Wolffers.

Paris.

Insulation of Underground Wires.

In your issues of the 17th and 24th of June and July 1st last, there appeared a series of articles on the insulation of electric light conductors, wherein very favourable mention was made of India-rubber and of Callender's process as insulators, but the Berthoud-Borel system was treated with somewhat less indulgence.

While theoretically there can be no question as to the excellence of rubber, when of good quality, for insulating conductors on which powerful currents are carried, and for use in exposed positions, it cannot be said that actual practice always confirms this opinion. It is very evident, however, that this unfortunate difference between theory and practice arises not from any inherent defect in rubber, but from the inferior quality of the compositions supplied by manufacturers generally, for it is no secret that in many, one might even say most cases, rubber forms but a very small percentage in what are fancifully termed "rubber" covered leads. It is a pity that but few opportunities are afforded for ascertaining the true value of thoroughly good admixtures of this material.

Turning to the Berthoud-Borel and Callender processes, you must permit me to differ with you in your apparent partiality towards the latter system. The former, though defective in many points, seems to possess reasonable and scientific elements, while the latter is a reversion to the most antiquated of all forms, many varieties of which are being daily tried in the United States and as frequently abandoned. Not that *per se* is there any harm in attempting to reconstruct an old building on new plans, but *pace* your opinion, Sir, recent experience of the Callender system in an installation of some magnitude in a certain important town on the Continent, does not lead me to place much faith in this method of insulating and protecting underground wires, though no doubt there are many instances where its employment has been fairly successful. From what I have seen and read of the results attending the employment of bitumen and bituminous compounds, the Callender process, to have attained the success claimed for it, must have indeed worked wonders with the natural qualities of this material.

Your contemporary, the *Lumière Electrique*, in its numbers for August 20th and 27th, describes at some length the advantages claimed by the Berthoud-Borel system over all others, for the insulating and protecting of underground wires for telephonic, telegraphic, and electric lighting purposes.

While not denying the successful employment of this process in many instances, I would solicit a little of your valuable space to discuss certain defects which I believe it to possess.

An undeniable source of weakness is the use of cotton or other fibrous material in immediate proximity to the conductor. The well known tendency of these substances to absorb moisture through capillary attraction, indeed, their great affinity for water to the exclusion of all other matter, renders their employment dangerous, *more especially as they are unprotected by any thoroughly efficient outer insulating covering.*

No doubt that in the process under notice very great pains are taken in the attempt to prevent any moisture

reaching the cotton or hemp, but even admitting that these attempts are successful up to a certain point, it requires but a little imperfection in, or slight accident to, the lead coverings for the insulation to be at once destroyed. In this respect gutta-percha and India-rubber are vastly superior, for their outer coverings (either lead or iron pipes) merely serve as mechanical protection, and were they punctured or cracked, the insulation, so long as the dielectric received no violence, would be in no way prejudiced.

The second point which demands consideration is the insulating material with which the cotton or hemp is impregnated. I believe experiments to a considerable extent were made with an admixture of paraffin and colophane or some other resinous substance. The objection to paraffin when used alone is that while cooling it shrinks, and although it mixes readily with resins, it has been found that when so blended an uneven cooling takes places owing to its want of affinity (hence the name *parum-affinis*) with other bodies. The specific gravity of resins ranges from 1·044 to 1·237, while that of paraffin is 0·906, a very great difference. This shrinking forms fissures in the mixtures, consequently the insulation becomes imperfect.

Another defect, as it appears to me, is the employment of a resin which in time must become brittle, thus rendering the disturbing of the cables an operation fruitful of danger.

The acids natural to paraffin, and those employed in its distillation and refining, are nearly all eliminated, but the process is expensive and one requiring great attention if thoroughly carried out, and even then as experience has shown, there frequently remain free acids in quantities sufficient to injure fibrous materials.

M. Wunschendorff, in a very interesting series of articles on submarine telegraphy, which have appeared in the late numbers of the *Lumière Electrique*, says of this process :—"Un autre essai quise poursuit depuis plusieurs années également à Paris, sur le câble de la société Berthoud-Borel et Cie., ne semble pas devoir être plus heureux. Le diélectrique de ce câble est formé de coton saturé de paraffine et de colophane additionée de camphre : le tout est étiré à travers une double enveloppe de plomb."

According to the *Lumière Electrique*, the Berthoud-Borel insulating compound, as at present manufactured, differs somewhat from the process just described. It consists of an admixture of linseed oil oxidised in a special manner with resin. The linseed oil is kept at boiling point for several days so as to get rid of all moisture.

The process is thus described :—The copper conductor, covered with one or more coats of cotton or hemp, is coiled round a drum of perforated sheet iron. The drum is then plunged into a cauldron filled with the insulating compound in a liquid state at a temperature of 180° centigrade (356° Fahrenheit), in which it is kept until all moisture has been expelled from the cotton or hemp. The drum is then placed in a closed case and carried to a press which covers the conductor with the lead coatings, and is so arranged that any length can be covered without the necessity of jointing. As an extra precaution against the admission of any moisture, there is in connection with the press a small tank from which the insulating compound runs in a boiling state over the conductor. The first covering of lead is coated with a thin layer of tar, and a second application of lead then follows.

Now, the statement that the oil is boiled for two or three days in order to extract the moisture is totally wrong, this being an operation which can be performed in a very short time. The boiling for this lengthy period, if in the presence of air, oxidises the oil, naturally tending to resinify it. This is probably the intention, so that by solidifying and hardening the oil it may be brought nearer to the specific gravity of resin and consequently mix better ; but it appears to me that the oxidised oil when cooling becomes of a far too resinous consistency, and this, in view of the brittle nature of resins, constitutes a dangerous element, since the composition thus becomes insufficiently plastic.

We are told that the ingredients are kept in a liquid state at a very high temperature. They will consequently take up the positions due to their respective specific gravities, which are : linseed oil, 0·94 ; resin, 1·044 to 1·237 ; the heavier naturally sinking. There will, therefore, be an uneven distribution of the insulating mixture, and a subsequent uneven cooling of a mass irregularly mixed and far from homogeneous. The result of this must be that the cotton or hemp receives to a very limited extent a thorough impregnation of the *mixture*, and over the greater part of its surface is subject to the dangers arising from a very imperfect insulator.

The question of mixing resins with other bodies so that a homogeneous mass may be obtained, plastic enough, on the one hand, and sufficiently hard on the other, presents many difficulties. Resins when employed alone possess very great heat-resisting qualities, but if mixed with the lighter oils, the latter from their solvent action, enormously diminish this property ; a very important consideration when dealing with electric light conductors.

I have already mentioned some objections to the use of cotton or hemp. I may add that fibrous materials are not only liable to injury from the fatty acids contained in oils, but the subjecting of them to great heat enormously weakens their mechanical attributes.

I now come to the lead coverings. Though the manner in which the lead is applied possesses many advantages, it is admitted that a second covering has been found necessary, owing to the possibility of defects existing in the first coat ; and here the weakness of the system is patent. It is not such an easy matter to obtain lead so pure that there will not be some weak spots in it. At these places moisture will assuredly be admitted and leakage will consequently take place, for it must be remembered that the insulation does not depend entirely, as it does in the case of gutta-percha or India-rubber, on the insulating material with which the conductor is covered, but to a great extent relies on the lead coatings and thin layer of tar.

We are told that the adding of an extra lead pipe with a thin coat of tar is analogous to the covering of a wire with two or three separate coats of percha and layers of compound ; the author is apparently unaware that the various coats of percha become amalgamated into one solid mass of insulating material, a quality which can hardly be claimed for any number of superimposed lead coverings.

The fatty acids contained in oils are not only dangerous to fibrous material, but also seriously affect metals, lead being especially susceptible, and I believe I am correct in stating that tar contains acids deleterious to lead and iron.

These lead-covered cables are very clumsy to handle, more especially when they have, as is often the case, to be threaded in and out of a number of gas, water, and drain pipes, and there is always the uncomfortable feeling attendant upon the use of resinous compositions, that a too sharp bend or twist is likely to produce a crack or fissure in the insulating compound.

My excuse for encroaching upon your space to such a length must be the general interest of the subject of insulation for underground wires.

W.

P.S.—Does not the Eddison system lately referred to by Mr. Preece at a meeting of the Telegraph Engineers bear a very distinct family likeness to the Berthoud-Borel process ?

Incandescent Lamp Patents.

I have read Mr. Sinclair's letter which appeared in your issue of a fortnight ago with considerable amusement. This gentleman, whoever he may be, has taken upon himself to criticise a case upon which he evidently knows nothing, nor does the recorded information published give the points he discusses. I have endea-

voured to find out who this gentleman is, but find he is apparently unknown in leading circles of scientific men. But there is one thing certain ; this would-be admirer of certain expert witnesses never concocted that letter signed by him. Under these circumstances I feel he must not be allowed to pose as a contributor without a protest from me, as it is certainly presumptuous on his part to offer an opinion upon evidence he admits he did not hear ; but in order to enlighten him as to this case, perhaps he would be surprised to hear that both Dr. Fleming and also Mr. Gimingham swore that they had tested a certain lamp supplied by me to plaintiffs' solicitor, and found it a vacuum lamp, whereas it was nothing of the kind, although it was upon this very sworn evidence that a case of alleged infringement was got up, and granted by the court against me, but upon this point Mr. Sinclair had better wait until he has heard evidence which will be produced on my side in due course upon proceedings pending. Fortunately for me, this particular lamp on which the case rests is still in existence, it having been impounded, although the socket was the only portion produced at the late trial, it being sworn that the lamp had been broken. It may, therefore, astonish Mr. Sinclair to know that if I prove this, my case is won, and monopoly prevented, which I shall be able to do on the next occasion, probably by the evidence of Mr. Hamilton and other well-known experts, which have been secured and retained by me. Mr. Sinclair has only to inspect the evidence given by Dr. Hopkinson in the W. and R. case and compare it with that given in mine, and he can judge for himself as to merits of the same. Mr. Sinclair may also probably be surprised to learn that Prof. Dewar stated in court, amidst roars of laughter, that he found 101 per cent. of carbon (in addition to the ash discovered) in some of my filaments, which, if true, must have been a different filament to those prepared by the Edison process from lampblack and tar, or even bamboo cane. Perhaps Mr. Sinclair would also be surprised to learn that the Edison and Swan Company sell 100 Swan lamps to one of the Edison type; and whatever lamps have been sold either in England or abroad, of an Edison type are made under patents of 1882 and later dates, and not 4,576 of 1879.

Perhaps he would also be surprised to learn, if he does not already know it, that Mr. Lane-Fox was in the meantime in the market with a lamp of high resistance containing a carbonaceous filament and other elements of a modern incandescent lamp, and this, too, long before an Edison lamp was ever seen in England by any person or persons the company can produce, who can, and will swear to these facts ; consequently when the action is fought upon the proper footing between the Brush Company and the Edison and Swan Company, there is no doubt that the Brush Company will win—which action and evidence will prove who was the first and true inventor of the modern incandescent lamp, and also who is entitled to the laurels, which at present is a matter of dispute. Personally, I cannot lay claim to have invented a lamp of high resistance, but I can, with confidence, state that I am the true inventor of the best low-resistance battery lamp yet introduced, which little lamp has done good work, and has been the pioneer of securing many large contracts to other firms, who have made money out of the seed sown by

Arthur Shippey.

September 1st, 1887.

Testing Dynamos.

I observe in your last issue that Mr. Swinburne describes a method of testing dynamos which he considers superior to other methods from which it was probably deduced. I quite agree with him that it is exceedingly simple and convenient, but its accuracy is, I am afraid, very questionable.

I have taken the test he mentions on several dynamos of different types, in connection with other tests, on two machines connected together by belt, varying the load on the generator.

By separately exciting the fields and running first with full load on the motor, then with about half load, then with external circuit of generator broken but the machine fully excited, then with the generator unexcited, and lastly, the motor alone without load, keeping speed constant throughout, a set of equations are obtained, which I will not trouble you with, but which should give ample data for determining the losses in each machine and in the belt, and this I find, when carefully performed, is approximately the case in machines of the Crompton type ; but in other machines, and especially in those of the Victoria type, the results are very conflicting. In all machines I have tried, however, the absolute efficiency certainly increases as the load is increased, and there is some approach to a constant loss in undirected power.

According to Mr. Swinburne's theory, machines should always be worked up to their full capacity to obtain good efficiency, and this I believe to be the case ; we have systematically overworked machines, that is to say, taken more current out of them than what they were designed for, without ill effects.

It is quite another matter, however, to run machines at excessive speed. The gain in electrical efficiency is, of course, in this case obvious enough, but whether there is any real gain is more doubtful, and I certainly believe the loss in undirected or stray power increases at least as the speed of rotation if not in a higher ratio. The growing custom of making slow speed dynamos is probably based on experience.

Naturally, makers of dynamos prefer a test which gives very little trouble and which with new machines in their own hands is certain to give good results ; but I fancy most purchasers of dynamos would prefer my method, in which the power is really developed and measured.

The reason why I never said anything about my method for so long was, that at that time the idea of their dynamos being used as motors was simply terrifying to the makers.

Another subject I should like to mention is that of the proper volts to be kept on a large arc lamp. In a note in your last issue you state that this should be between 45 and 50 volts for all currents. We have had considerable experience in search lights up to 200 ampères, and we find that the volts to give the best burning increase slowly with the current, the equation $v = 40 + \cdot 12\ c.$ giving about the best result. I believe this to be made up of about 35 volts back E.M.F., and the rest employed in driving the current through a true resistance $= \frac{5}{c} + \cdot 12.$

We always use compound wound machines for search lights, but I am inclined to think that the characteristic should rise considerably with the current, the machine being kept well excited by the shunt coil on open circuit.

Simple series winding is quite inapplicable for large machines. The best solution for lighthouse work is, in my opinion, continuous current from accumulators if several lamps, each concentrated in one direction, can be adapted. When an all round light is necessary, alternating currents are preferable.

The question of the lamp, if 15 or 20 volts can be allowed for regulation, should be easily solved by expending a little money on experiment.

P. Cardew.

Chatham, *August 30th*, 1887.

Slow Speed v. High Speed Dynamos.

In the issue of the ELECTRICAL REVIEW for August 26th, Mr. Swinburne strongly condemns the use of slow speed dynamos. As a believer in slow speed machines and in their usefulness, I cannot allow his remarks to pass without some protest. Mr. Swinburne gives economy of space, when direct driven, as apparently their only advantage. Now, as a matter of

fact, there are many applications of dynamos where a belt driven slow speed machine is a great advantage, if not a necessity, for instance, in copper refining works where the machines are required to run day and night for considerable periods of time; or taking the case of a machine exported to the Colonies, where repairs are difficult and sometimes impossible, very few engineers would recommend a high speed machine for this purpose.

The advantages of slow speed machines may be summed up as follows:—Practical freedom from breakdown; less attention required to run them; considerable saving in repairs to commutator, brushes, and bearings, and in a heavy current machine the much greater ease with which the current is taken from the commutator.

Mr. Swinburne takes a 50,000 watt dynamo, running at 1,200 per minute, with an electrical efficiency of 94 per cent., reducing the speed to 400 per minute, the same machine gives only 13,120 at an efficiency of 71 per cent. In my opinion a much fairer comparison would be to take a larger machine and reduce its speed till its output and that of its high speed rival were the same, the electrical efficiency of the two machines would be approximately, high speed machine 94 per cent., low speed machine 90 per cent. It is evident that the Foucault currents in the low speed machine will have only one-fourth the intensity of those in the high speed machine, meaning a considerable saving in stray power. The cost of countershaft, pulleys, extra belt, pedestals, and fixing same will go a long way towards reducing the difference in price between the two machines. The gross efficiency of the two machines, one running by belt direct off engine flywheel and the other machine being run through an intermediate countershaft, will be nearly equal. Mr. Swinburne's remarks on self-induction are very opportune. I have often been asked, when stating the efficiency of a machine, if I had allowed anything for the loss due to the self-induction of the armature; of course self-induction causes only a loss of output, not of power. I can fully confirm Mr. Swinburne's statement as to the good qualities of shunt-wound motors. The performance of these machines under varying loads would really astonish those who believe that a self-regulating motor must be compound wound. I have read Mr. Swinburne's ably written articles with much pleasure, and am sorry to have to differ with him on the subject of slow speed dynamos.

W. H. Eaves.

Telephones not Patented.

My remarks published in the REVIEW of July 22nd were not intended by me, nor do I think they can be considered to be criticisms on the letter of Mr. John S. Ross in the REVIEW of 24th June. I frankly admit that I was mistaken in stating that Mr. Ross "erred in stating that the 'English Mechanic' receiver was described in Bell's patent." I was led into that mistake by the statement of Mr. Ross that "in consequence of the publication in the *English Mechanic* the great 1876 patent had to file its renowned disclaimer."

In Mr. Ross's letter in the REVIEW of July 29th, he writes that "although there are not set descriptions of the E.M.T. in Bell's disclaimer, yet, nevertheless, I will maintain this, viz., that it was that instrument which brought about the disclaimer."

The answer is that the owner of a patent cannot disclaim anything not in the patent. The disclaimer was necessitated by the publication of the claims and drawings of Bell's U.S. patent of March 7th, 1876, published in the "Official Gazette" of the United States Patent Office on March 7th, 1876, and on file in the British Patent Office July 3rd, 1876. Now the disclaimer was for "the cone having a membrane stretched over one end with one end of an armature attached to its centre, the other end attached to the uncovered leg of an electro-magnet," represented in fig. 19 of Bell's English patent. The "English Mechanic" receiver I knew well years ago was published in August, 1876; but I am correct in my statement that the membrane telephone with the small piece of iron attached to its centre was first mentioned by Bell before the Society of Telegraph Engineers, October, 1877. I meant to assert the fact that that was the *first* time *Bell* himself spoke of such an instrument in England.

The word membrane, according to the Imperial Dictionary by Dr. Ogilvie, "is the term applied to thin expanded parts of various textures, both in animals and vegetables." "There are three kinds, mucous, serous, and fibrous." Now it cannot be denied that wood is fibrous, that mica is fibrous, and that vulcanite is mucous, and, when either of these substances are thin, they come under the description of the word membrane. In fact, French scientists term the iron tympan in Bell's telephone a membrane. In regard to the Glasgow receiver with a thick iron disk, as stated in my letter, if Mr. Ross will try such an instrument he will be convinced that its articulation of speech is much more distinct than the articulation of any Bell's receiver. It is well known to scientists that the thicker the tympan and the smaller, the more distinct is the articulation; but, at the same time, the loudness is greatly diminished, because the extent of the vibration is diminished. Mr. Ross should have tested such an instrument before he should have called in question my statement. Mr. Bell has no claim for tympanic vibration.

The Glasgow receiver had "an iron disc attached at one point only, and not touching at any other point." This was the description of it by Sir George Jessel, who held it to be an anticipation of Bell's receiver with the disc held down all round its circumference. I submit that a Glasgow receiver with a thick iron disc is "legally and morally free" from any claims in the Bell patent, as also the Bourseul-Cox-Walker electro-magneto receiver, and the "English Mechanic" receiver. I do not wish to enter into any controversy with anyone, but when I make a statement which I know of my own knowledge to be true, I think it uncourteous to deny the truth of my statements without having tested the fact, and merely upon an hypothesis.

W. C. Barney.

New York, *August 26th*, 1887.

Barney's Telephones.

I desire to call the attention of your readers, scientific men and practical mechanics, to English patent, No. 11,662, of September 14th, 1886. These specifications describe instruments which transmit intermittent pulsations which have all the qualities essential for the reproduction of articulate speech. This is the result of my experiments begun in October, 1884, and spoken of in the REVIEW, pages 21 and 22, January 3rd, 1885, and page 88, January 23rd, 1885.

On examination of the construction of the instrument, it will be seen that the tympan must, when vibrated by air waves, make and break contacts. Of this there cannot be any question.

That this instrument sends intermittent pulsations which cause a magneto-telephone to reproduce articulate speech with great distinctness is daily witnessed by a number of persons who carry on continued conversation by means of it.

I will add that I do not use carbon of any kind. The contact points are of metal. The receiver I use with this transmitter is described in English patent, No. 11,660, September 14th, 1886.

Both of these inventions were made by me, and I have patents for them both in the United States, dated February 8th, 1887.

I am inclined to believe that I have accomplished two results generally denied to be possible, namely, 1. The reproduction of articulate speech by means of makes and breaks of the circuit; 2. The use of metal contacts for that purpose.

W. C. Barney.

New York, *August 26th*, 1887.